UNCLASSIFIED

AD NUMBER
AD597060
CLASSIFICATION CHANGES
TO: unclassified
FROM: secret
LIMITATION CHANGES
TO: Approved for public release, distribution unlimited
FROM: Distribution authorized to DoD only; Foreign Government Information; MAR 1973. Other requests shall be referred to British Embassy, 3100 Massachusetts Ave., NW, Washington, DC 20008.
AUTHORITY
DSTL ltr, 20 Dec 2007; DSTL ltr, 20 Dec 2007

THIS PAGE IS UNCLASSIFIED

U.D.C. No.

623·946·21·1:
623·946·001·4:
623·827·039·578

A.U.W.E. Tech. Note 484/73
MARCH 1973

THE EFFECT OF SUBMARINE MAXIMUM SPEED ON THE HIT PROBABILITY OF AN AIR-LAUNCHED TORPEDO (U)

BY

A.E. JONES

A.U.W.E. Tech. Note 484/73

ADMIRALTY UNDERWATER WEAPONS ESTABLISHMENT

PORTLAND

CONDITIONS OF RELEASE

1. This information is released by the UK Government to the recipient Government for defence purposes only.
2. This information must be accorded the same degree of security protection as that accorded thereto by the UK Government.
3. This information may be disclosed only within the Defence Departments of the recipient Government, except as otherwise authorised by the Ministry of Defence/Aviation.
4. This information may be subject to privately-owned rights.

AMENDMENTS

NUMBER	1	2	3	4	5	6	7	8	9	10
DATE										

CONDITIONS OF RELEASE

1. This information is released for information only [illegible] treated as disclosed in confidence. The recipient Government [illegible] its best endeavours to ensure that this information is not dealt with in any manner likely to prejudice the rights of any owner thereof to obtain patent or other statutory protection therefor.
2. Before any use is made of this information for the purpose of manufacture, the authorisation of the Ministry of Defence [illegible] be obtained.

U.D.C. No. 623.946.21.1:
623.946.001.4:
623.827.039.578

A.U.W.E. Technical Note 484/73
March, 1973

THE EFFECT OF SUBMARINE MAXIMUM SPEED ON THE HIT PROBABILITY OF AN AIR-LAUNCHED TORPEDO (U)

by

A. E. Jones

CONTENTS

ILLUSTRATIONS

Figure

ILLUSTRATIONS (CONT'D.)

DISTRIBUTION

	Copy No.
D.W.C.A.	1
D.R.U.W.	2
D.R.I.C.	3 to 24
D.A.R.L.	25
D.C.S.(N)	26
D.N.O.S.	27
P.P.A.G.	28
D.O.A.E.	29

THE EFFECT OF SUBMARINE MAXIMUM SPEED ON THE HIT PROBABILITY OF AN AIR-LAUNCHED TORPEDO

PRÉCIS

1. This report provides a method of evaluating the effect of an increase in maximum submarine speed on the hit probability of an air-dropped torpedo. Curves are given from which it is possible to determine torpedo hit probability as a function of target speed for various weapon systems, torpedo characteristics, and target characteristics. The theory is applied to typical systems involving the air-launched torpedo, and the parameter values are selected to show what could be achieved within the timescale of a future generation submarine.

CONCLUSIONS

2. The significance of a worthwhile decrease in torpedo hit probability with an increase in submarine maximum speed depends critically on the choice of weapon parameters.

3. In the case of a torpedo with the characteristics of the NASR 7511, increased submarine maximum speed up to 40 knots is only valuable if it is being exploited at the commencement of the torpedo attack.

4. In the case of a weapon with a speed of only 35 knots, an active acquisition range of 1200 metres and the same endurance as the NASR 7511, there appears to be a considerable gain for the submarine if its maximum speed is increased to 35 knots.

5. Submarine reaction time, up to 30 seconds, does not appreciably affect the torpedo hit probability for weapon acquisition delay times of 30 seconds.

INTRODUCTION

1. One of the major factors affecting the hit probability of an anti-submarine torpedo is the maximum possible speed of the target. A submarine which is travelling at maximum speed, or one that has the time to accelerate from a slower speed, may have the capability of being outside the torpedo's acquisition circle at the instant the torpedo enables. In this case the torpedo is said to be acquisition limited. Furthermore, if the torpedo has acquired its target, a high maximum speed may enable the submarine to outrun the torpedo, thus considerably reducing the hit probability. The torpedo is then said to be endurance limited. The submarine speed range of interest is from 25 to 40 knots, since values in excess of 25 knots are currently achievable, and 40 knots is technically feasible.

AIM

2. The aim of this report is to provide a means for determining the effect of an increase in submarine maximum speed on the air-dropped torpedo hit probability. Any increase in maximum speed on present levels is likely to be extremely costly, and only as a result of a complete cost effective study could a decision be made as to the merits of such a step. From the curves provided, the torpedo hit probability for different combinations of system dead time, attack error, submarine reaction time, etc. (see paragraph 8) can be determined as a function of submarine speed. To convert the hit probability to kill probability, the effectiveness of the torpedo warhead and the actual hit distribution on the target need to be taken into account, but this is outside the scope of this study.

THEORY OF THE MODEL

3. The torpedo hit probabilities are computed from a mathematical model involving the "cookie cutter" approach. In other words, for any target within the torpedo's acquisition volume the probability of acquisition is unity. The acquisition probability of the torpedo is thus determined by the percentage of the target distribution enclosed within the torpedo's acquisition circle after the average time required for acquisition has elapsed. The acquisition probability is then converted into a hit probability by a consideration of the sector of the acquisition circle over which the torpedo can catch the target. (See Annex A).

4. The distribution of the target positions is assumed to be bivariate circular normal, and is centred on the calculated position the submarine would reach during the system dead time. The system dead time is defined here as the total time available to the target for evasive manoeuvre, and is the time between the last usable sonar echo leaving the target until acquisition by the torpedo. The target distribution is defined by the radial r.m.s. attack error, which includes the errors in weapon delivery, in addition to the sonar errors and evasion prediction errors present.

5. The submarine is credited with a favourable constant acceleration and rate of turn capability, namely 15 knots per minute and 3 degrees per second respectively. These values are considered typical for present and future imminent nuclear submarines. However, any variation in the acceleration and turn rate could be allowed for by a corresponding variation in the submarine's reaction time.

6. It is assumed that, in most cases, the torpedo will be aimed at a predicted position based on the attacker's best estimate of the target's course and speed (i.e. the ideal splash point, ISP). Alternatively, the torpedo may be aimed at the last sonar fix. Thus, for a torpedo drop involving prediction against an "unalerted" target (i.e. a submarine travelling at an initial speed in excess of

 PRECEDING PAGE BLANK-NOT FILMED

20 knots, such that the self noise level is assumed to be too high to allow the torpedo threat to be heard) the centre of the torpedo acquisition circle will coincide with the peak of the target distribution. However, if the attacker does not use prediction against an unalerted target, the peak of the target distribution will be ahead of the centre of the torpedo acquisition circle by the distance travelled by the submarine during the system dead time.

7. An "alerted" target (i.e. initial submarine speed up to 20 knots) is assumed to take immediate evasive action by turning and accelerating away from the torpedo splash area when alerted to the torpedo threat. In this study, the slower submarine is assumed to be alerted at torpedo water entry, although, in fact, the alert would most likely occur later; for example, when the torpedo motor starts up. A reaction time - up to a maximum of 30 seconds - is allowed for the submarine to appreciate the threat and initiate its turn onto the evasion course. The optimum evasion course is assumed to be radially away from the torpedo splash point. Thus, in the case of an alerted target, the centre of the torpedo acquisition circle, or ISP, is offset (if the reaction time is less than the acquisition time) from the peak of the target distribution, irrespective of whether the attacker uses prediction or not.

RANGE OF PARAMETERS CONSIDERED

8. The following ranges of parameters are considered:-

(a) Torpedo acquisition range:- 1200, 1800, 2400 metres.

(b) Radial r.m.s. attack error:- 250, 500, 750, 1000, 1500, 2000 metres.

(c) Torpedo offset (i.e. the separation at acquisition between the centre of the torpedo acquisition circle and the peak of the distribution of target positions):- 0 to 3000 metres.

(d) Submarine reaction time:- 15, 30 seconds.

(e) Submarine speeds:-

(i) Alerted:- initial speeds of 10 and 20 knots, and maximum speed up to 40 knots.

(ii) Unalerted:- 30 to 40 knots.

(f) System dead time:- 40, 60, 80, 100, 120, 140 sec.

(g) Torpedo speed:- 35, 45 knots.

(h) Range 5, 10, 20 km.

(j) Standard deviation of sonar errors:-

range 1%) 2%)
bearing 1°) 2°)

9. The weapon system is defined by the parameters of (b), (c), (f) and (j), the terminal weapon characteristics by (a), (f) and (g), and the target characteristics by (b), (c), (d) and (e).

RESULTS

10. Curves are plotted from which it is possible to obtain torpedo hit probabilities under various conditions. Graph 1 shows the relationship between torpedo acquisition delay (time between torpedo release and acquisition - a component of the system dead time), offset distance of the torpedo from the target, and submarine reaction time.

11. Graphs 2 to 7 indicate how the radial r.m.s. attack error varies with target speed for a series of dead times, ranges and sonar inaccuracies. The radial r.m.s. error computed for an optimally evading (i.e. sinuating) target according to the least squares principle of reference 1 incorporates errors in sonar prediction, evasion prediction and delivery.

Thus $\sigma_T^2 = \sigma_{sp}^2 + \sigma_{ep}^2 + \sigma_d^2$

where σ_T is the total standard deviation of the attack error

σ_{sp} is the standard deviation of the sonar prediction error

σ_{ep} is the standard deviation of the evasion prediction error

and σ_d is the standard deviation of the delivery error.

The values of σ_{sp} and σ_{ep} are determined for the different attack systems using the theory in reference 1, and for σ_d a value of 100 metres is used. This latter value corresponds to the delivery error for the Mk. 44 torpedo drops from the Wasp helicopter as determined by the RN OEG (Reference 2).

12. Employing the theory of reference 1, the overall radial r.m.s. error is independent of target speed for a straight-running submarine, assuming constant speed, dead time and number of fixes. The evasion prediction error is thus zero in this case, with the result that the radial attack error is comprised solely of the sonar prediction and delivery errors. Hence, the radial attack error for a non-evading target is that shown in the curves for zero target speed.

13. Graphs 8 to 10 show, for the series of radial attack errors and acquisition ranges, the relationship between torpedo acquisition probability and the torpedo offset distance from the submarine at the average instant of acquisition. The associated curves 8a, 9a and 10a allow the acquisition probabilities to be converted into hit probabilities (See Annex A) for torpedo speeds of 35 and 45 knots.

USE OF RESULTS

14. It is envisaged that the curves be employed in the following sequence:-

(a) Offset distance of torpedo from target at acquisition is read off from Graph 1 for the torpedo acquisition delay and submarine reaction time under consideration.

(b) The radial r.m.s. attack error is determined from Graph 2 - 7 for the appropriate system dead time. Alternatively a pre-determined radial error may be considered (as in the Annexes B and C).

(c) The torpedo acquisition probability is read off for the appropriate offset and radial error.

(d) Finally, the torpedo hit probability is read off according to the torpedo speed and the speed of the submarine averaged over the duration of the torpedo's endurance.

15. Appendices B and C discuss the application of this theory to various weapon systems. In order to investigate the evasion capability of a future generation submarine it becomes necessary at the outset to make very broad assumptions regarding possible future enemy ASW weapons and systems likely to exist from 1985 onwards. The systems considered involve a lightweight air-dropped torpedo, and it seems reasonable to attribute to the enemy for the purposes of this study the torpedo and system improvements which we expect to possess during the timescale of a future generation submarine.

16. The characteristics of the proposed torpedo to NASR 7511 are considered appropriate for this timescale. The speed of the torpedo is 45 knots, it has a deep water active acquisition range of around 1800 metres, and also the ability to search rapidly in depth down to 2500 feet. In addition, the mean time required to enable and acquire (i.e. on average half-way round the first search circle) is relatively small - approximately 30 seconds. However, failure of the torpedo to acquire the target on the first search turn will considerably increase the submarine's chance of escape. This factor is not investigated in this report, and it is considered that further study would be necessary to determine the precise effect of delayed torpedo acquisition on the submarine's ability to escape.

17. Although at the present time the torpedo characteristics described above are regarded as appropriate for the latter part of the century, it is considered necessary to compare these results with those from an inferior weapon. In this way, the problem of making the weapon "too superior" for the submarine, so that high hit probabilities are maintained for submarine speeds in excess of 40 knots, is avoided. Thus, a torpedo with a speed of 35 knots and an acquisition range of 1200 metres, but with a similar endurance and acquisition delay time to the NASR 7511, is added to the attackers armoury.

18. It is stressed that, in Appendices B and C, the future submarine is evaluated against the optimum system likely to be encountered at the end of the century. In other words, it is pitched against the highest possible odds, and no account has been taken of the probability of occurrence of such a system.

REFERENCES

Reference

1 J.G. Schothorst - Errors in the Predicted Position of an Evasive Submarine and Development of Optimum Tactics. NATO Restricted. SACLANT ASW Research Centre Technical Report No. 48.

2 Operational Evaluation Report No. 1/70 - The MATCH System. Secret.

3 Mathematical Analysis of Ordinary and Deviated Pursuit Curves - Tufts College - Mathematical Research Project (Project RM-6).

4 Westland Aircraft Limited - Development of the Helicopter in the ASW Weapon System. Secret.

APPENDIX A: CALCULATION OF THE PROBABILITY OF THE TORPEDO HITTING THE TARGET AFTER ACQUISITION

1. The probability of the torpedo hitting its target after acquisition has occurred is determined from a consideration of the sector of the torpedo acquisition circle over which the weapon can catch the submarine in the allowed endurance. The probability depends on the following parameters:-

(a) Torpedo speed

(b) Submarine speed

(c) Torpedo acquisition range

(d) Torpedo endurance

(e) Bearing of the torpedo from the submarine at the commencement of the pursuit.

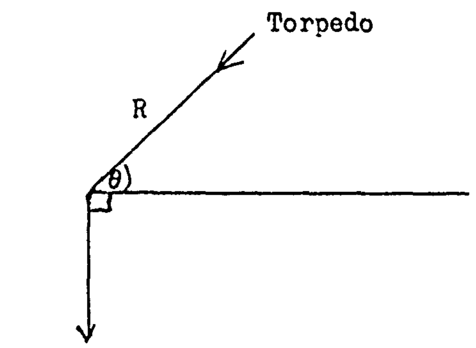

FIG. A1

2. Reference 3 gives the equation to calculate the time required for a successful pursuit.

Thus (see Fig. A1),

$$t = \frac{R}{V_{SM}(\lambda^2 - 1)} (\lambda + \sin\theta)$$

where t (sec) is the time required by the torpedo to catch the target after acquisition.

R is the initial separation between the torpedo and target (metres)

V_{SM} is the submarine speed (metres/sec)

λ is the ratio of torpedo speed to target speed

θ is the limiting angle on the beam.

3. Substituting values of V_{SM}, λ and t into the above equation allows values of θ to be calculated for various initial separations between torpedo and submarine. Thus, a contour may be constructed on the acquisition circle, showing the proportion of torpedoes able to catch the target while travelling on a pursuit course.

APPENDIX B: WEAPON SYSTEMS INVOLVING RELATIVELY LONG DEAD TIMES

1. The weapon system involving a long dead time chosen to demonstrate the theory is the single helicopter with dipping sonar operating in the SELFTAC mode.

2. The effects of extending the sonar capability of the large helicopter are considered. The airborne dunking sonar is effectively a high speed VDS, with the additional advantage that its track is virtually completely random. At present, the 195 sonar searches over a 90° sector at a time, but for the purposes of this study, a 360° scanning sonar set with the same average detection range (6000 metres) as sonar 195 has been assumed. This type of sonar would considerably reduce the time spent in the dip, and it has an improved search rate of up to 40% on the 195 (Reference 4).

3. The operation of the single helicopter in the SELFTAC mode is that, after obtaining the initial detection with its dipped sonar, the helicopter raises the sonar and attempts to close the range by flying to the fix and dipping again. This process is continued ideally until the range-to-target has reached a constand minimum value. If on any dip the target is detected close enough, or if the range has been minimised, the sonar is raised, the helicopter flies to the fix and the torpedo is launched.

4. The success of the helicopter SELFTAC is dependent on the following variable parameters:-

(a) The target speed - determines the separation of the torpedo splash point from the submarine at the instant that the torpedo enables. In addition, the initial target speed determines whether or not the torpedo is alerted to the impending torpedo attack.

(b) The torpedo characteristics, such as acquisition range, enablement time, speed, etc.

(c) The dead time of the system.

(d) The dip cycle - the time which elapses between each sonar dip. This depends on such factors as the wind speed, the time required to house the sonar ball, and the time taken by the helicopter to come out of the hover and accelerate to the drop point (essentially dependent on the wind direction). After a number of dips, there is a minimum distance, determined by the dip cycle in conjunction with the target speed, to which the helicopter can close the submarine. This minimum distance of closure varies from 1700 metres for a 20 knot target to approximately 4000 metres for a 40 knot target.

(e) System errors.

5. Operating in the SELFTAC mode, the helicopter must always aim to drop its weapon at the last known target position. This is due to the fact that the helicopter SELFTAC involves high dead time, during which the target may appreciably alter course and speed, and prediction of the future target position becomes virtually impossible.

COMPONENTS OF SYSTEM DEAD TIME

6. The following times are taken to be representative of the component delays in the dead time:-

	100ft Search Depth	230ft Search Depth
Ping (one-way travel time) (R=3 km)	2 sec	2 sec
Raise sonar ball	21 sec	35 sec
House sonar ball (average)	31 sec	31 sec
Accelerate to drop point	45 sec	45 sec
Torpedo delay from launch to acquisition	30 sec	30 sec
TOTAL	129 sec	143 sec

The time quoted to house the sonar ball is an average time, taking into account any possible swinging that may occur as the ball is winched up. In addition, the helicopter's course to the drop point is totally dependent on the wind direction, and the acceleration time to the drop point is computed accordingly.

7. Figures 11 to 14 indicate how the torpedo hit probability changes with target maximum speed for alerted and unalerted submarines. Radial errors of 500 and 1000 metres are considered, along with system dead times of 100 and 140 seconds - these times conveniently cover the range discussed in paragraph 6.

RESULTS AND CONCLUSIONS

8. 35 knots/1200 metre acquisition range torpedo:

(a) Alerted Submarine (Figs. 11 and 12)

Figures 11 and 12 indicate that while the torpedo hit probabilities fall of considerably for target speeds in excess of 30 knots, the hit probability is extremely dependent on the initial speed. A submarine travelling at an initial speed of 20 knots until alerted and having a maximum speed of 30 knots has up to 55% more chance of escape (radial error 1000 metres, dead time 140 sec) than a submarine with initial speed 10 knots. Furthermore, the time that the submarine takes to react to the torpedo attack (up to 30 seconds) is not an important factor effecting the torpedo's performance - this is undoubtedly due to the relatively short time that the torpedo takes to acquire.

(b) Unalerted Submarine (Fig. 13)

In the case of an unalerted target travelling at high (constant) speed torpedo hit probability is relatively lower than for the alerted target and falls to zero at a target speed of 35 knots - i.e. the torpedo cannot catch a submarine travelling faster than itself, since it travels on a pursuit, not intercept, course. Dead time is critical in an attack against the high speed target, and with a radial attack error of 1000 metres, an increase in dead time from 100 seconds to 140 seconds (29% increase) decreases the torpedo hit probability from .21 to .05 (76% decrease).

9. 45 knot/1800 metre acquisition range torpedo:

(a) Alerted Submarine (Fig. 14)

A negligible drop off in torpedo hit probability is observed for submarine speed capability of up to 40 knots. Submarine reaction time in the range 0 to 30 seconds also has a negligible effect on the torpedo's hitting performance and again, the submarine's chance of escape increases with increasing initial speed at alert, especially at the high dead time.

(b) Unalerted Submarine (Fig. 14)

The torpedo hit probability shows a significant decrease for submarine speed in the range 30 to 40 knots, with attack error and dead time being very critical factors.

APPENDIX C: WEAPON SYSTEMS INVOLVING RELATIVELY SHORT DEAD TIMES

1. The "short dead time" system discussed is the MATCH system. The anti-submarine frigates fitted with this system carry a light helicopter which is used to deliver a homing torpedo to the area of the ship's sonar contact. The weapon-carrying helicopter carries no sensors itself; its attack is controlled entirely by the parent ship.

2. The probability of success of a MATCH attack against a sonar contact depends mainly on the following parameters:-

(a) The target speed

(b) The system dead time

(c) The torpedo characteristics

(d) System errors; that is the accuracy to which the ship can guide the helicopter to a drop position relative to the submarine. The torpedo is aimed at the predicted target position.

3. The delay components for the present MATCH system comprise :-

(a) Control Dealys, i.e. the period up to weapon splash, and

(b) Acquisition delays, or the period from weapon splash to acquisition.

Control Delays. Its components are irrespective of the type of terminal weapon used:-

Last usable echo starts to return from the target (zero time) (R = 9km)

Echo received	after 6 sec
Sonar cut transmitted	after 2 sec
Sonar position plotted	after 2 sec
Splash point predicted	after 5 sec
New vector ordered	after 3 sec
Aircraft turned, drop ordered	after 5 sec
Water entry	after 4 sec
	(Total 27 sec)

The delay of 6 seconds in receiving the echo assumes that the echo is received in just sufficient time for the aircraft to adjust its course and drop its torpedo at the revised position. In fact, an attack may be based on sonar information arriving up to one data interval beforehand. A "mid-way" allowance of 7½ seconds is made for this (assuming sonar scale 10). The total control delay is therefore 27 + 7½ = 34½ seconds.

Acquisition Delays

Enablement (average)	after 24 sec
Half first search turn	after 14 sec
	(Total 38 sec)

Thus, for Mk. 44 Torpedo attacks, a total delay time of $72\frac{1}{2}$ seconds is to be allowed.

4. This is the average time to acquisition if the target is in the right depth bracket for the initial search turn. It could be as much as 300 seconds if the target is deep.

Discussion of Improvements in Dead Time Components during timescale of a future submarine

5. (a) Sonar staleness:- this cannot be avoided or reduced - it is a function solely of target range and the velocity of sound in water.

(b) Plotting and prediction delays:- could be made virtually negligible by the use of a computer.

(c) Aircraft Manoeuvre:- the 8 second manoeuvre time for the helicopter would be almost halved if the aircraft could manoeuvre at 1g (improved prediction would reduce the necessity for severe manoeuvres though).

(d) Airflight of Weapon:- the airflight would be reduced by 1 second if the torpedo were released from a height of 100 feet.

(e) Data Cycle delay:- this is linked to the sonar transmission interval, which in turn is related to the expected maximum range. The use of a computer to continuously up-date the ISP would eliminate this delay.

(f) Torpedo Acquisition Delays:- a weapon with a shorter delay to acquisition is required - the torpedo to NASR 7511 will reduce the acquisition delay by approximately 12 seconds.

6. Incorporating these improvements, the above list would then read:-

Sonar staleness	6 sec (9km Range)
Data injection delays	2 sec
Transmission of orders	3 sec
Data cycle delay	0 sec
Aircraft manoeuvre	4 sec
Airflight of weapon	3 sec
Enablement	
Half search turn	30 sec
TOTAL	48 sec

7. A more sophisticated torpedo would not be subject to the same degradation as that for the Mk. 44 described in paragraph 4. The search procedure of the NASR 7511, for instance, is designed such that the weapon should acquire very early after enablement.

RESULTS AND CONCLUSIONS

8. Graphs 15 to 18 indicate the fall off in torpedo hit probability with increasing submarine maximum speed above 30 knots. Radial r.m.s. errors of 250, 500 and 750 metres are considered - a typical error for a present-day MATCH attack is a 50% CEP of about 320 metres (radial r.m.s. error 385 metres - Reference 2) but this is applicable only to low speed targets. Since the torpedo is aimed at the predicted target position, the system dead time does not directly cause the torpedo to be offset from the submarine as in the previous example, but an offset may be involved if the target is alerted and has sufficient time to evade. However, the dead time does affect the radial attack error, which in turn affects the torpedo hit probability.

9. 35 knots/1200 metres acquisition range torpedo:-

(a) Alerted Submarine (Figs. 15 and 16)

The torpedo hit probability resulting from the MATCH system shows a significant decrease as submarine maximum speed is increased to 40 knots. Radial r.m.s. error, up to 750 metres, has very little effect on the torpedo's hitting performance as does the submarine's reaction time, although the effect of the latter becomes more significant at high submarine maximum speed and low initial speed.

(b) Unalerted Submarine (Fig. 17)

As in the previous Appendix, the torpedo hit probability falls to zero at 35 knots, and the radial attack error, up to 750 metres, does not significantly affect the overall torpedo performance.

10. 45 kts/1800 metres acquisition range (Fig. 18)

(a) Alerted Submarine

Negligible decrease in torpedo hit probability is observed for submarine speeds up to 40 knots. Submarine reaction time up to 30 seconds, radial r.m.s. errors up to 750 metres and initial speeds up to 20 knots all have virtually no effect on the overall torpedo hit probability.

(b) Unalerted Submarine

By virtue of the fact that the unalerted target is travelling at a higher constant speed than the initial speed of the alerted target, the torpedo hit probability begins to depart from unity at a lower submarine speed, i.e. at about 34 knots, decreasing by approximately 40% when the target speed has increased to 40 knots.

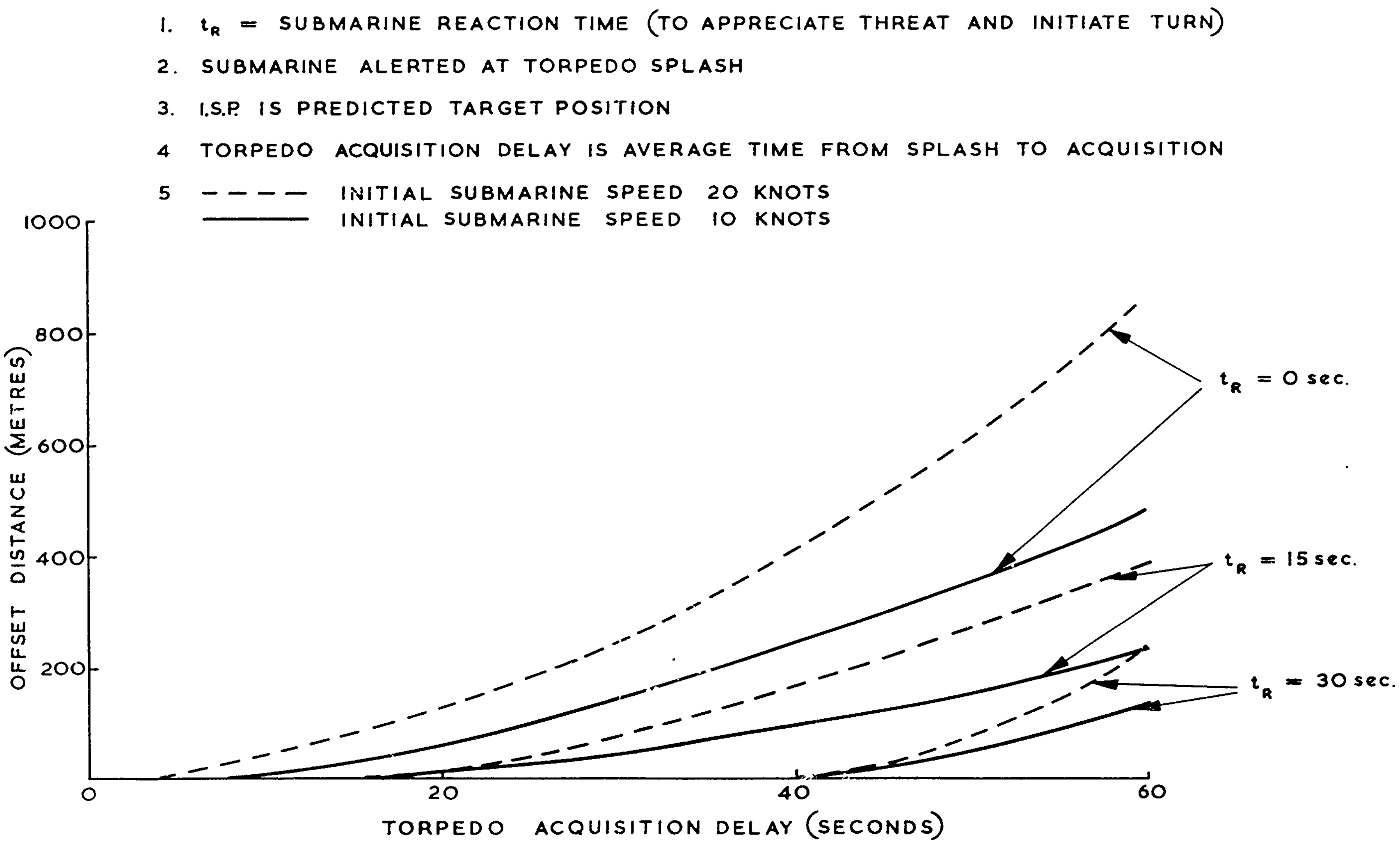

FIG. 1. SUBMARINE OFFSET DISTANCE FROM TORPEDO I.S.P. (ALERTED TARGET ONLY)

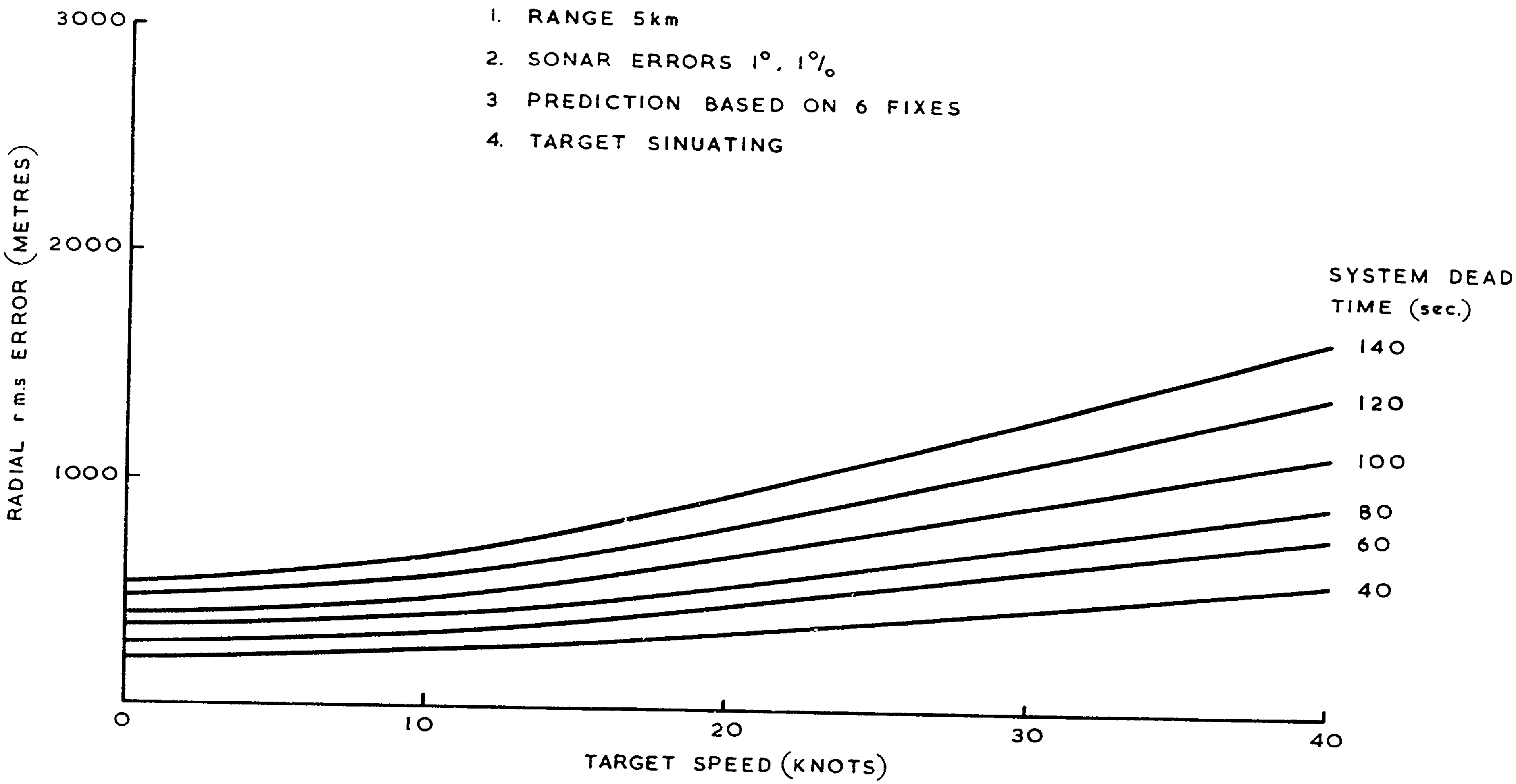

FIG. 2. RADIAL r.m.s. ATTACK ERROR AGAINST TARGET SPEED

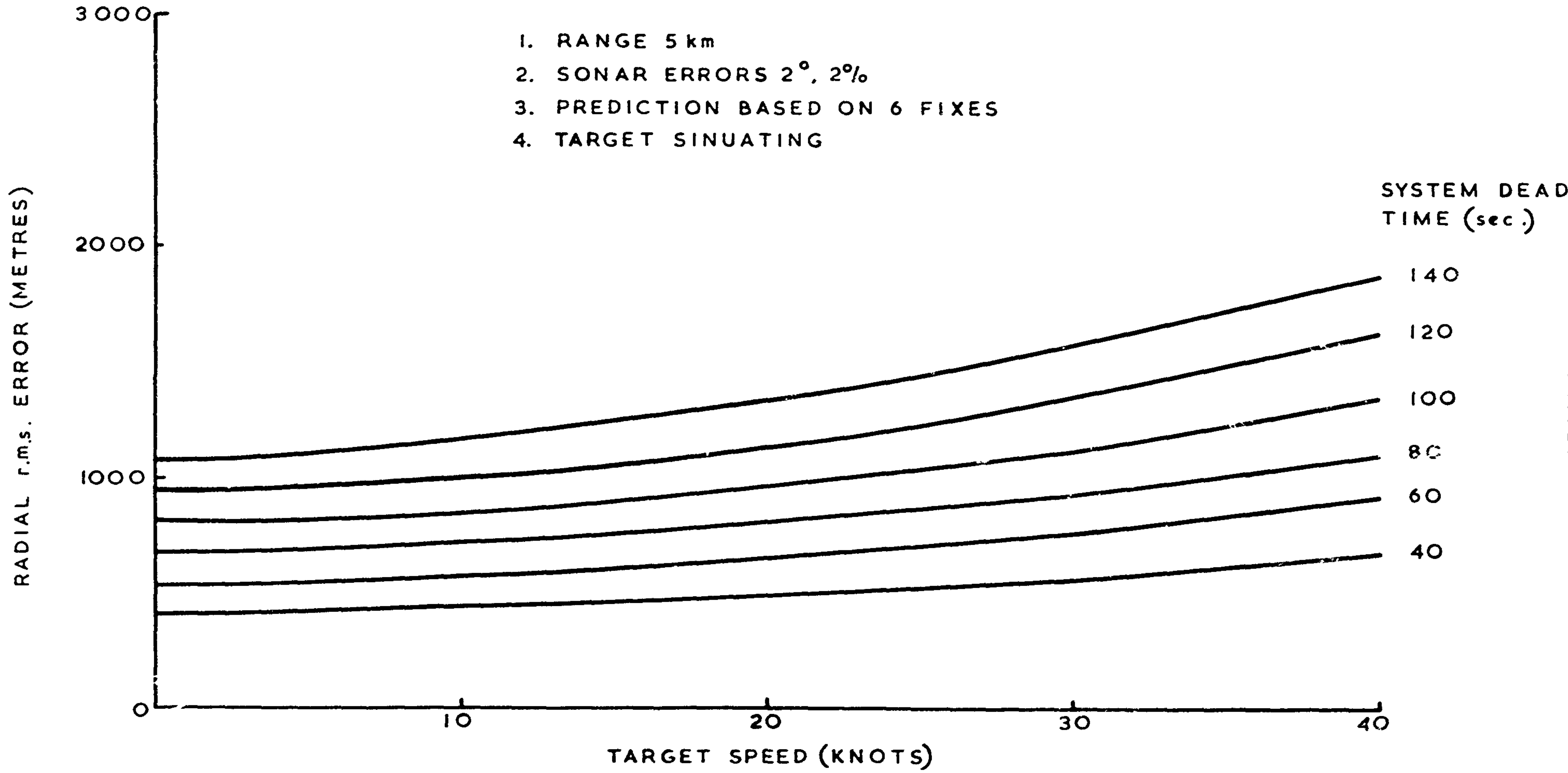

FIG. 3. RADIAL r.m.s. ATTACK ERROR AGAINST TARGET SPEED

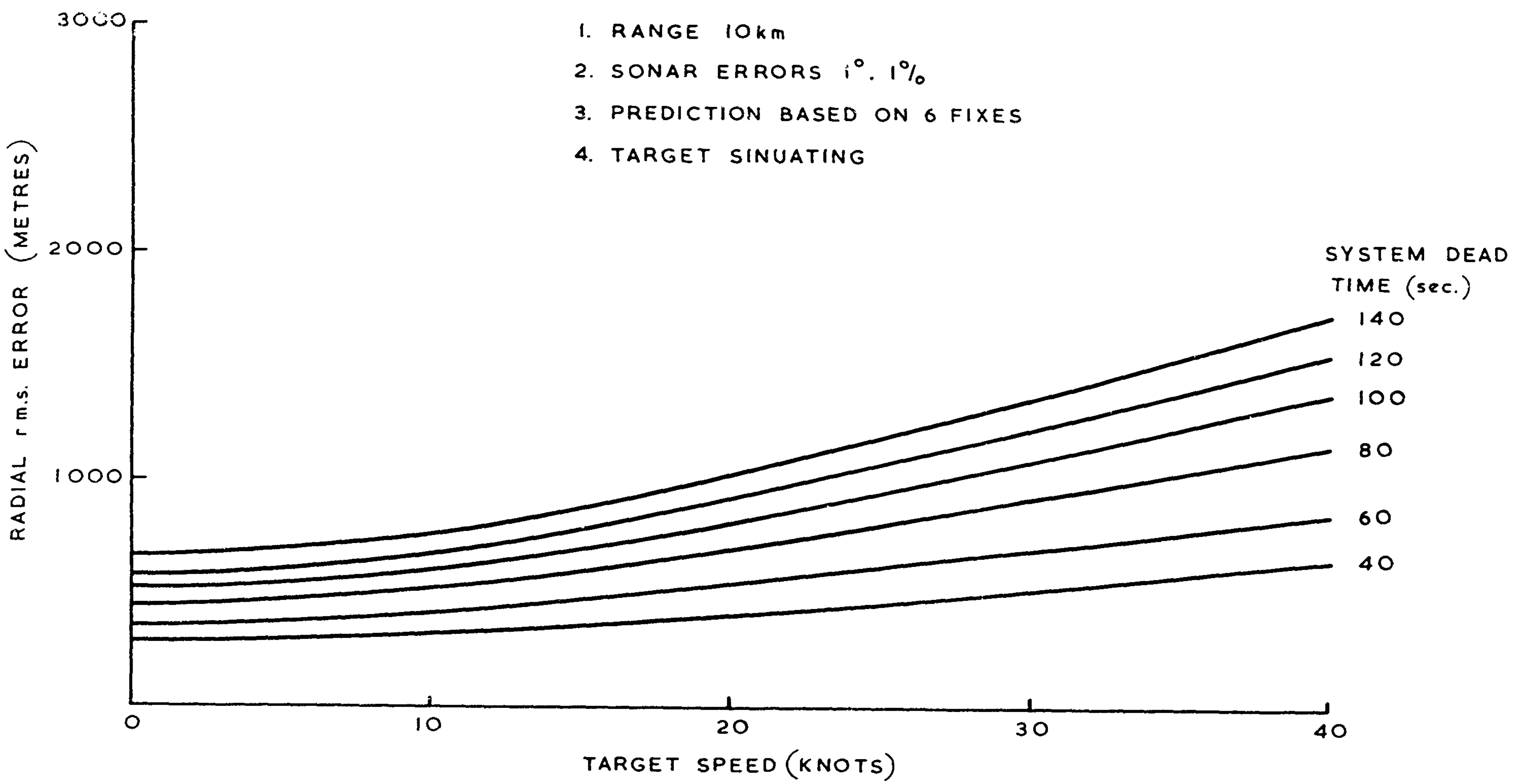

FIG. 4. RADIAL r.m.s. ATTACK ERROR AGAINST TARGET SPEED

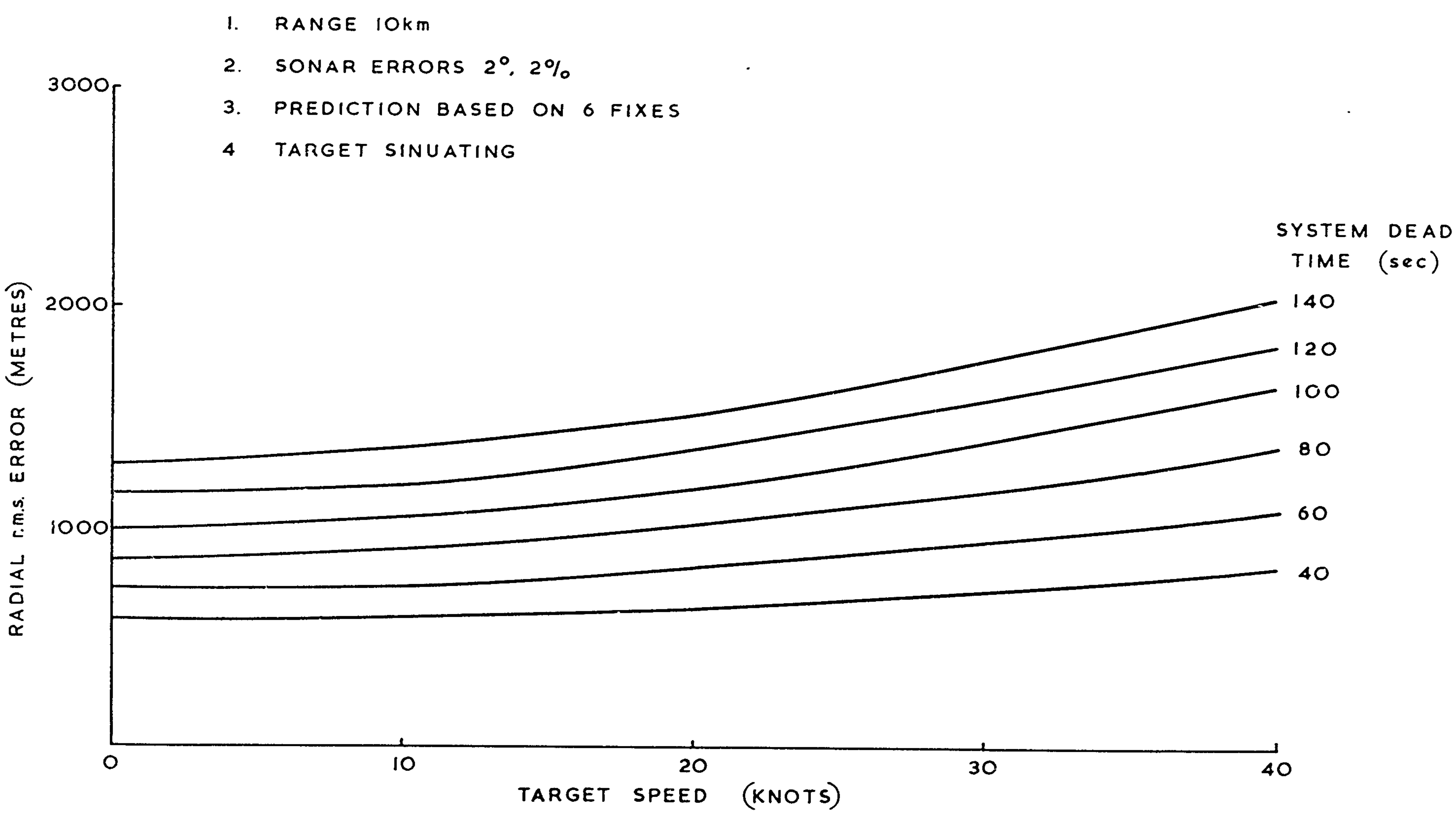

FIG. 5. RADIAL r.m.s. ERROR AGAINST TARGET SPEED

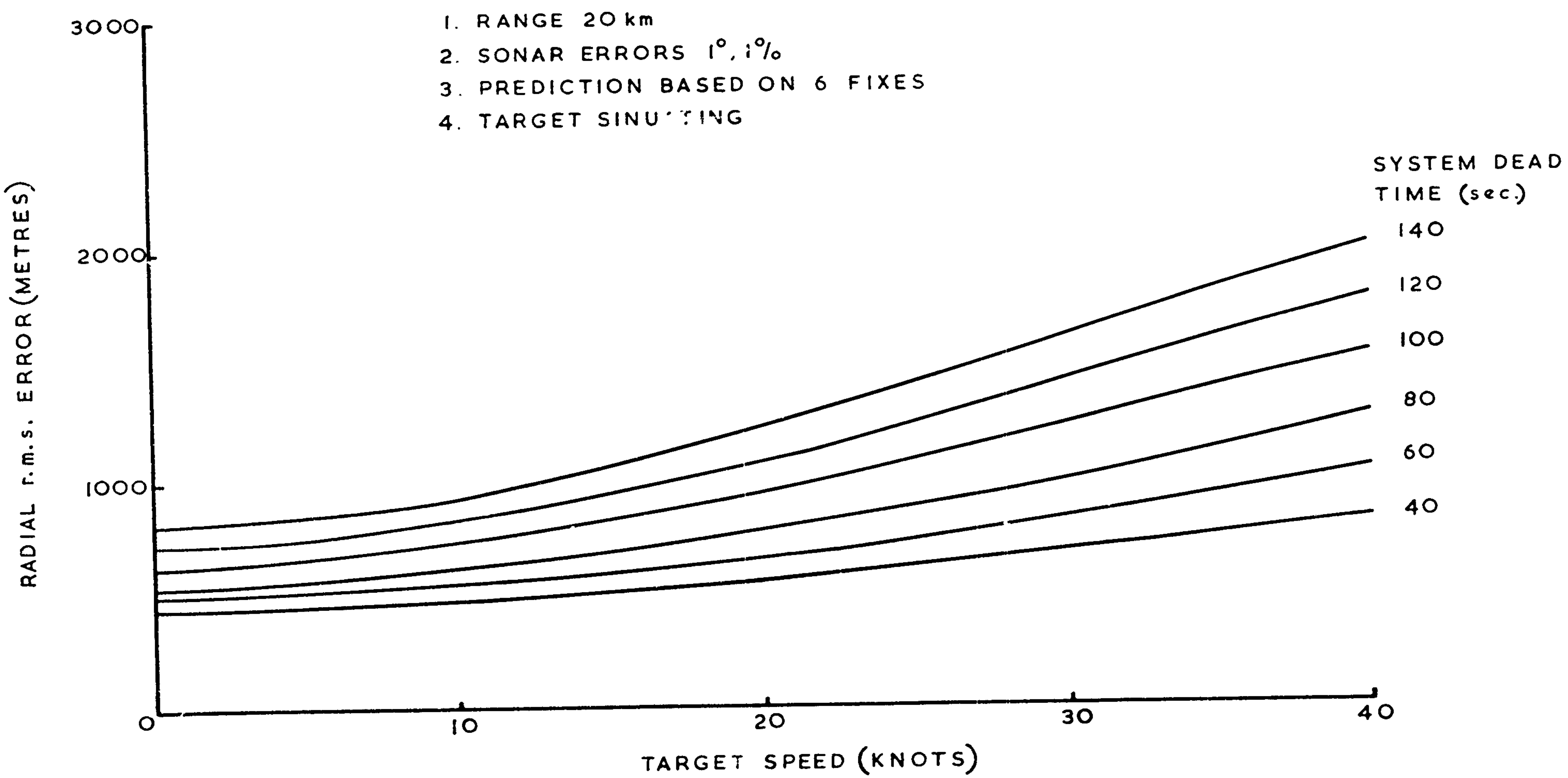

FIG.6. RADIAL r.m.s. ATTACK ERROR AGAINST TARGET SPEED

TN 484/73

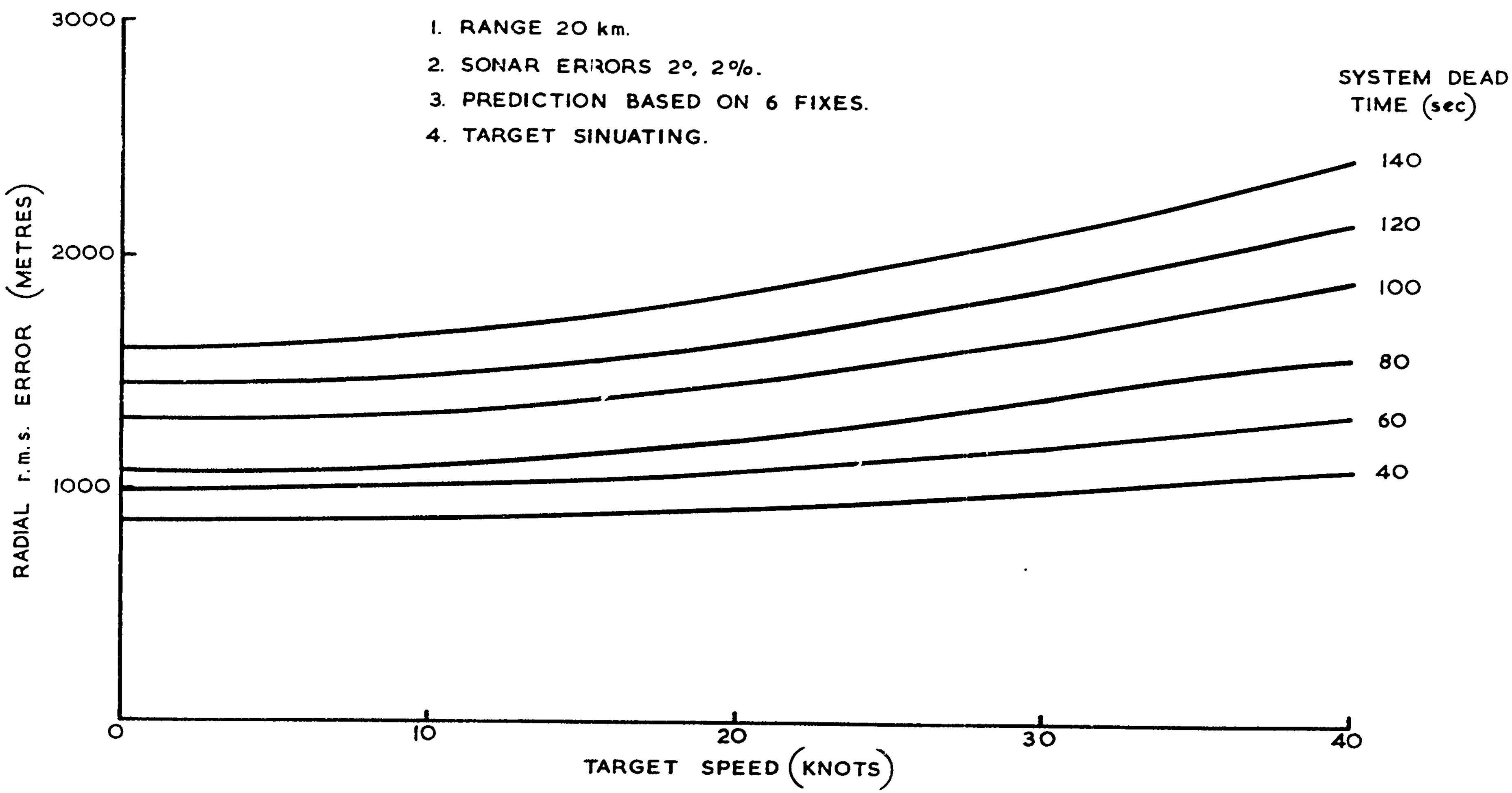

FIG. 7. RADIAL r.m.s. ATTACK ERROR AGAINST TARGET SPEED

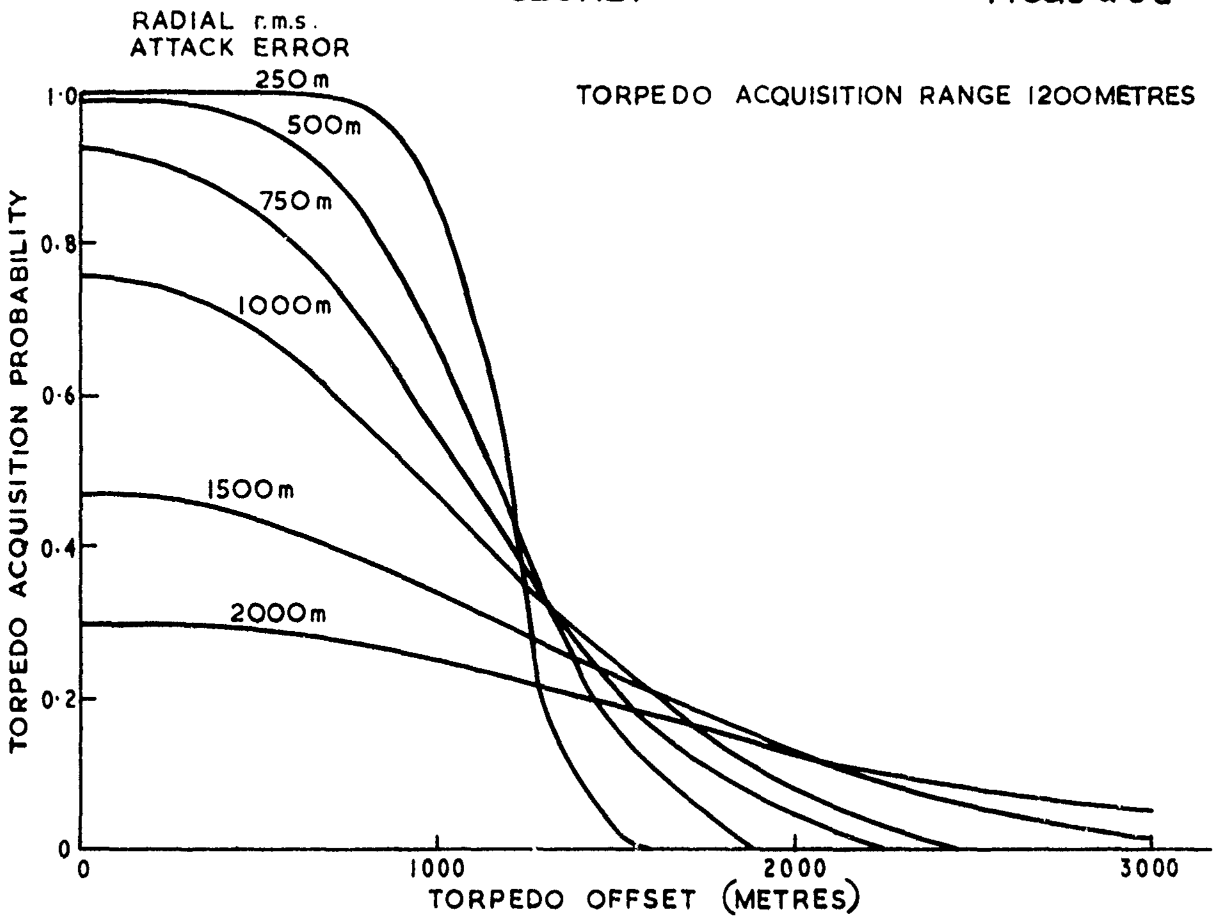

FIG. 8. TORPEDO ACQUISITION PROBABILITY AGAINST TORPEDO OFFSET

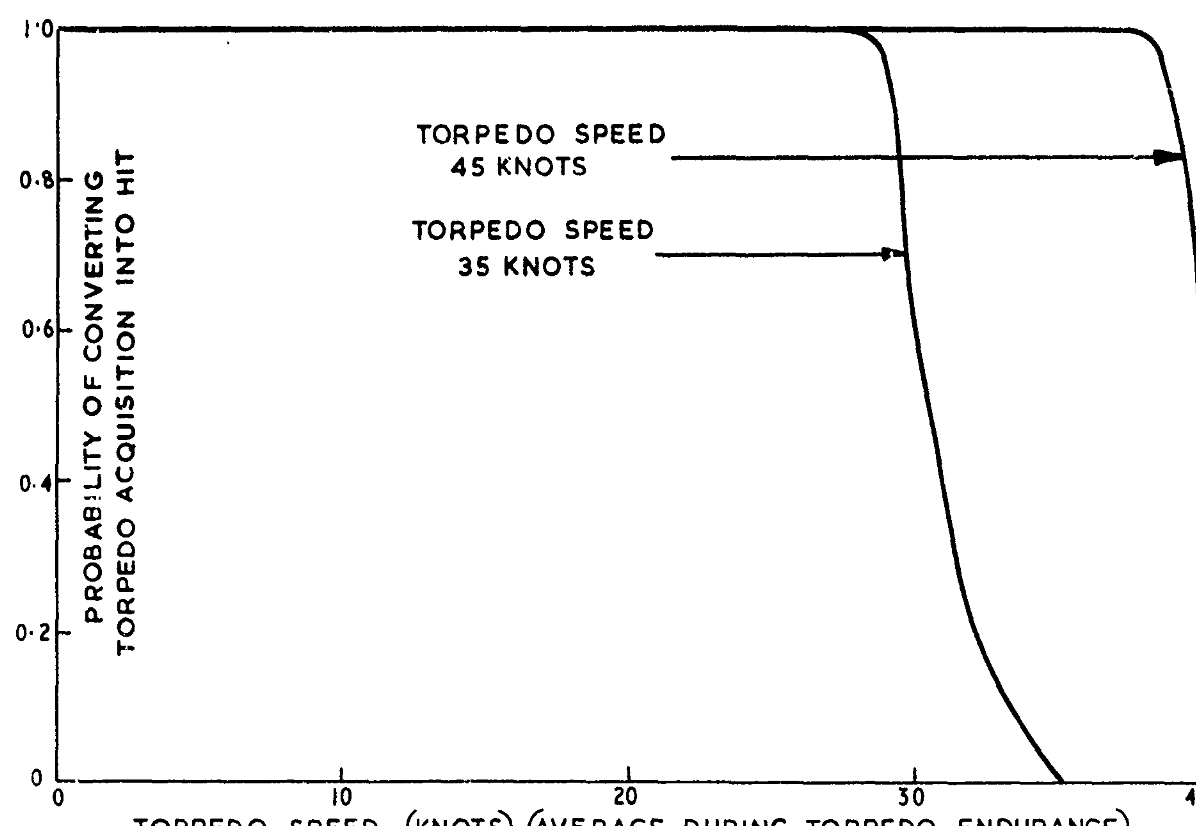

FIG.8a. PROBABILITY OF CONVERTING TORPEDO ACQUISITION INTO HIT AS A FUNCTION OF TARGET SPEED

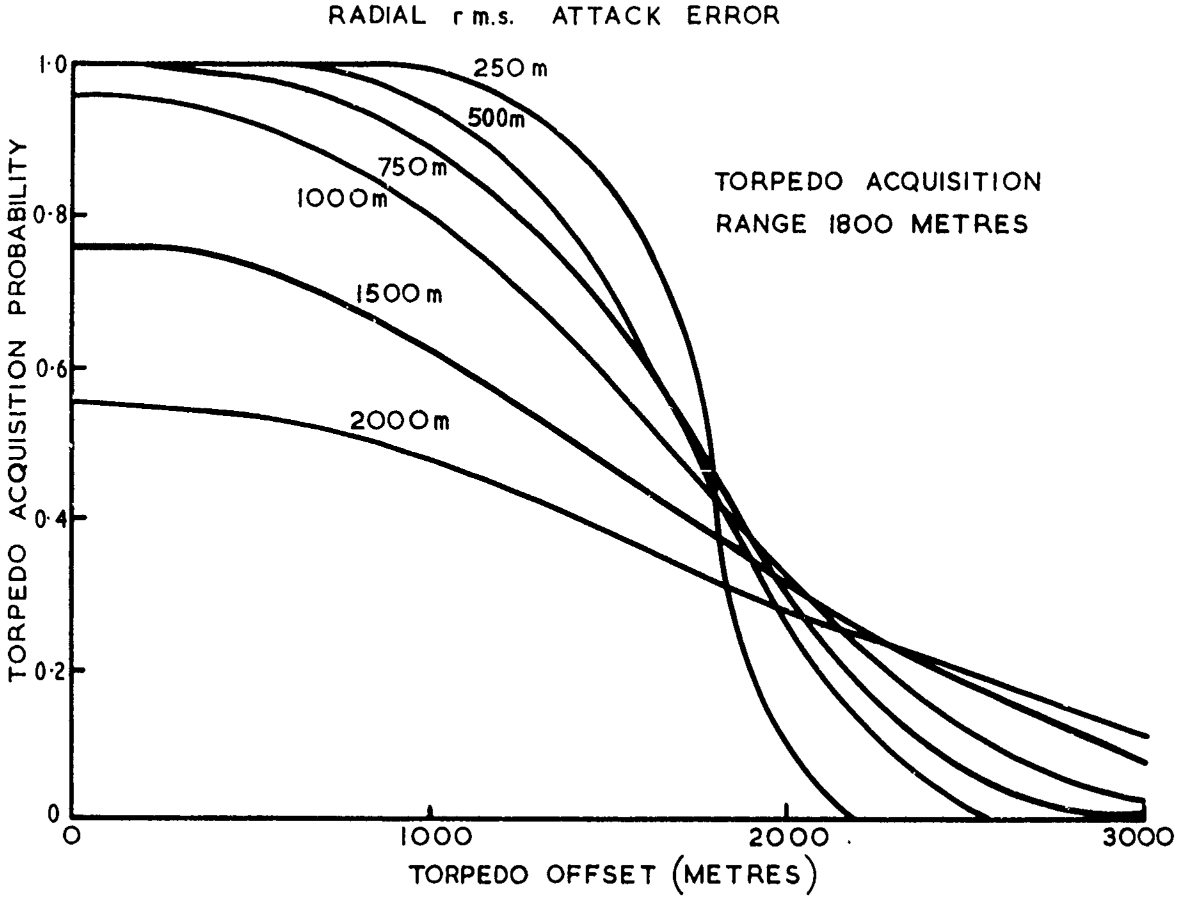

FIG. 9. TORPEDO ACQUISITION PROBABILITY AGAINST TORPEDO OFFSET

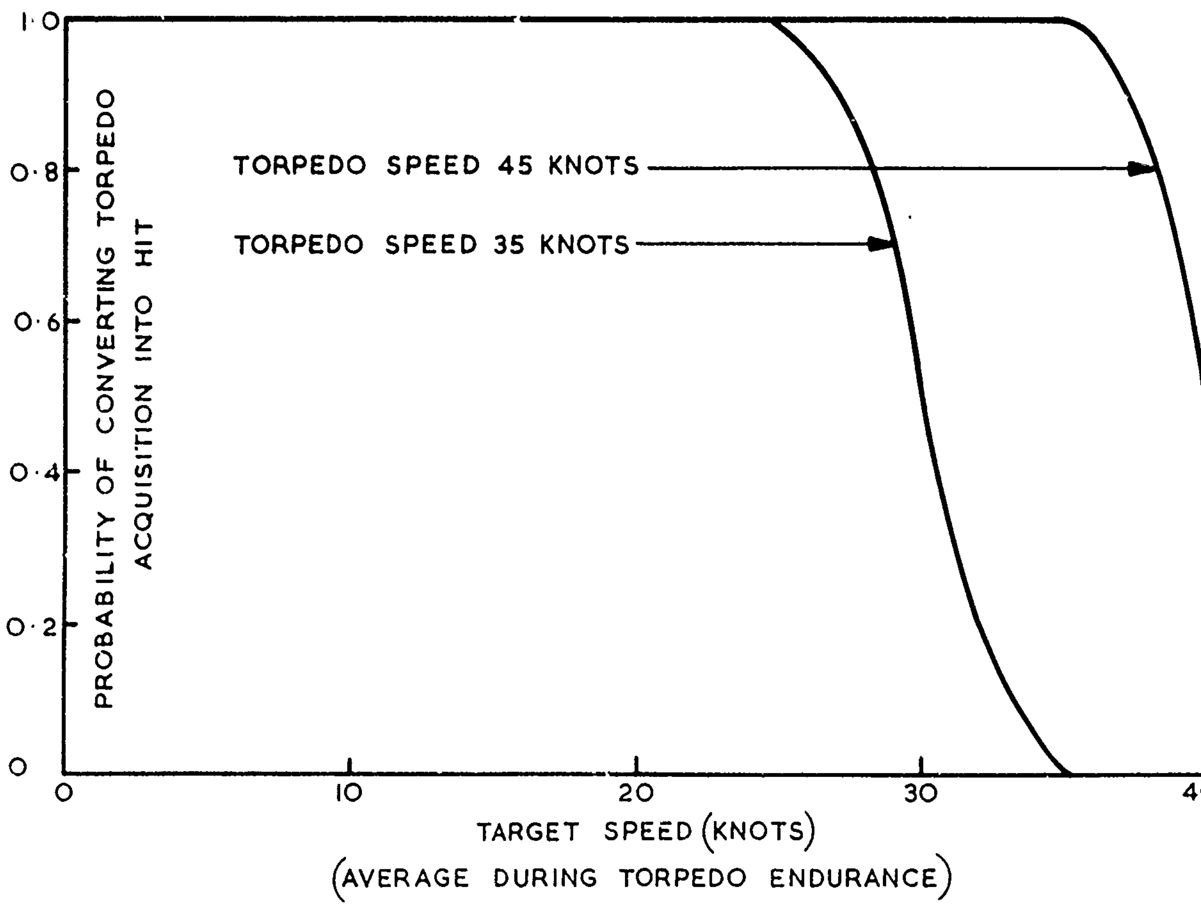

FIG. 9a. PROBABILITY OF CONVERTING TORPEDO ACQUISITION INTO HIT AS A FUNCTION OF TARGET SPEED

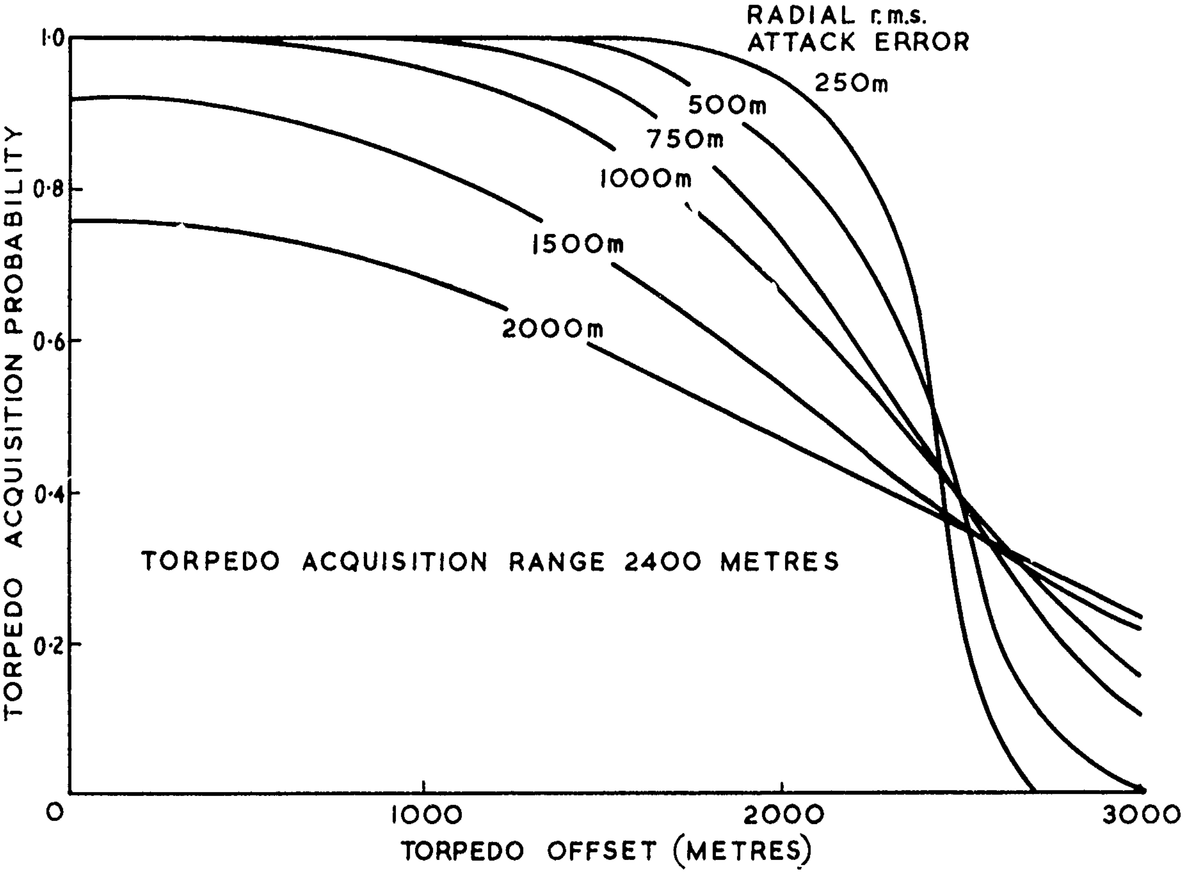

FIG. 10. TORPEDO ACQUISITION PROBABILITY AGAINST TORPEDO OFFSET

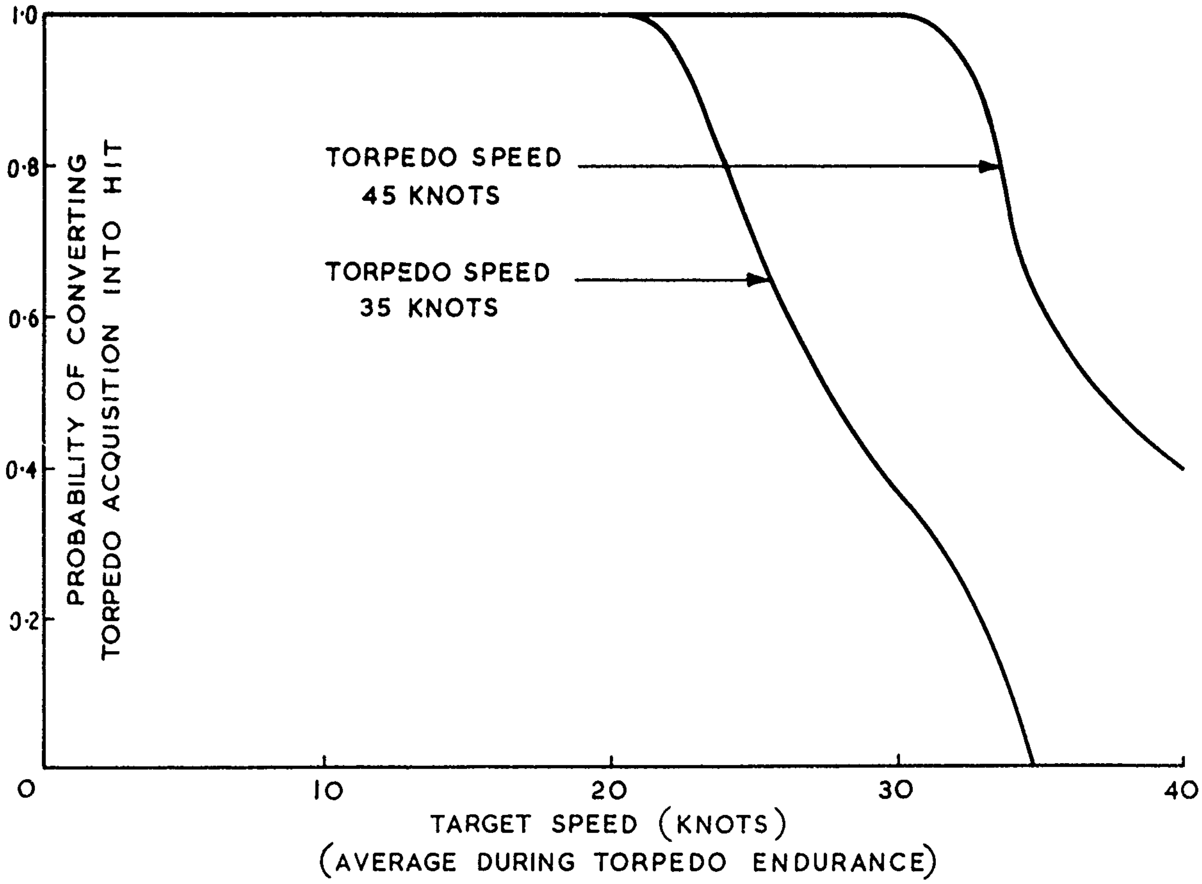

FIG. 10a. PROBABILITY OF CONVERTING TORPEDO ACQUISITION INTO HIT AS A FUNCTION OF TARGET SPEED

TN 484/73

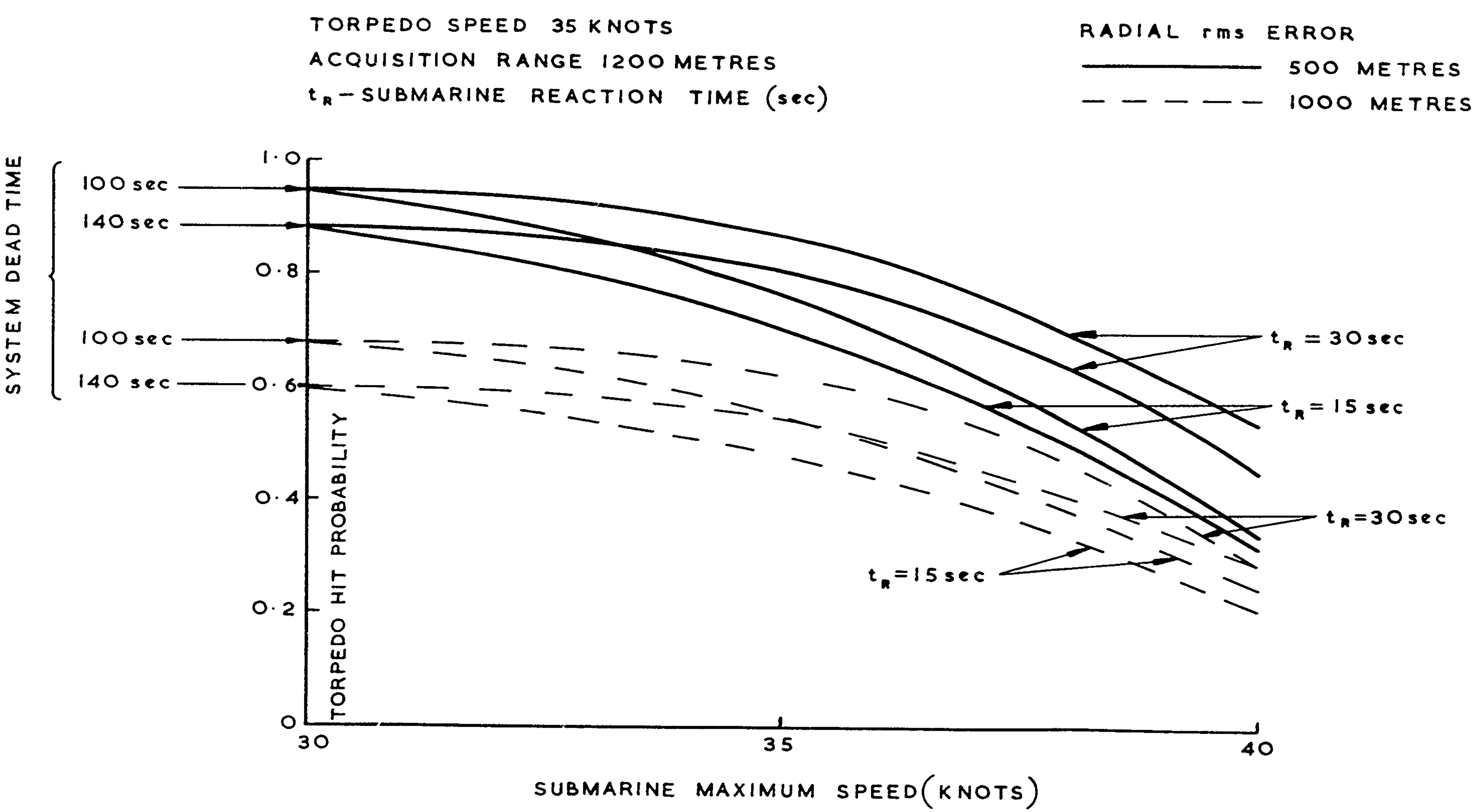

FIG. 11. TORPEDO HIT PROBABILITY AGAINST TARGET MAXIMUM SPEED. HELICOPTER SELFTAC–ALERTED SUBMARINE (INITIAL SPEED 10 KNOTS)

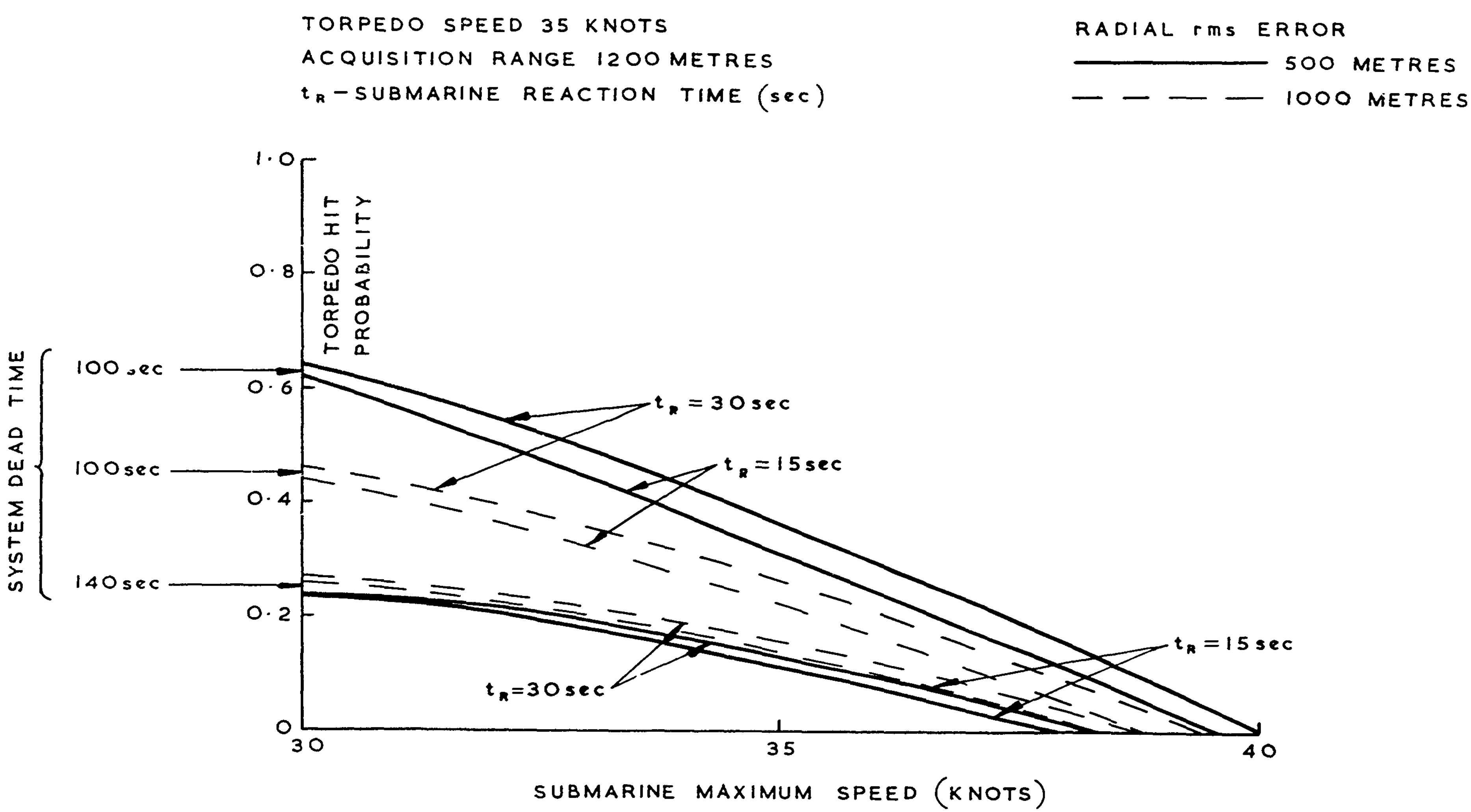

FIG. 12. TORPEDO HIT PROBABILITY AGAINST TARGET MAXIMUM SPEED. HELICOPTER SELFTAC–ALERTED SUBMARINE (INITIAL SPEED 20 KNOTS)

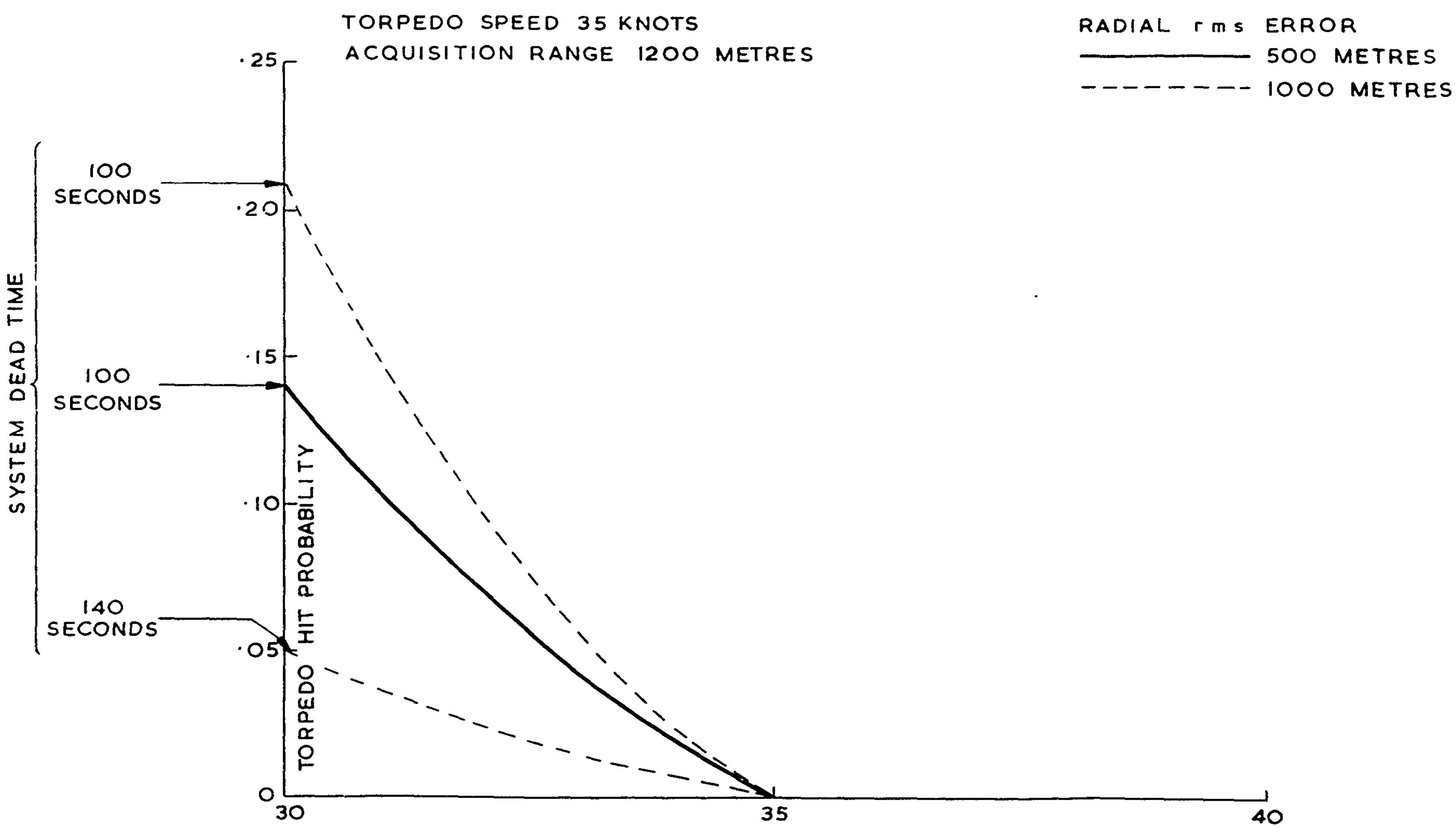

FIG. 13. TORPEDO HIT PROBABILITY AGAINST TARGET MAXIMUM SPEED.
HELICOPTER SELFTAC - UNALERTED TARGET

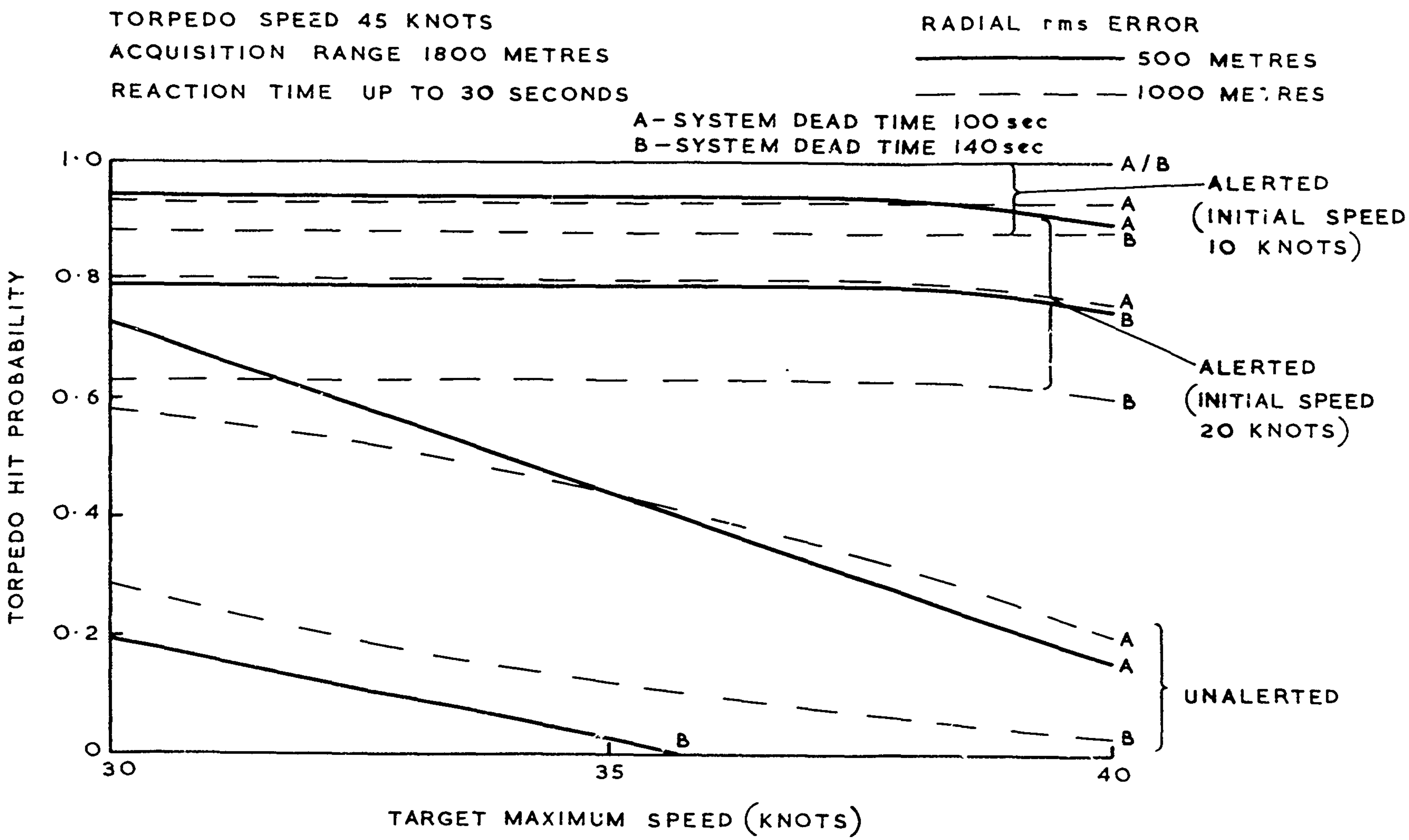

FIG. 14. TORPEDO HIT PROBABILITY AGAINST TARGET MAXIMUM SPEED.
HELICOPTER SELFTAC

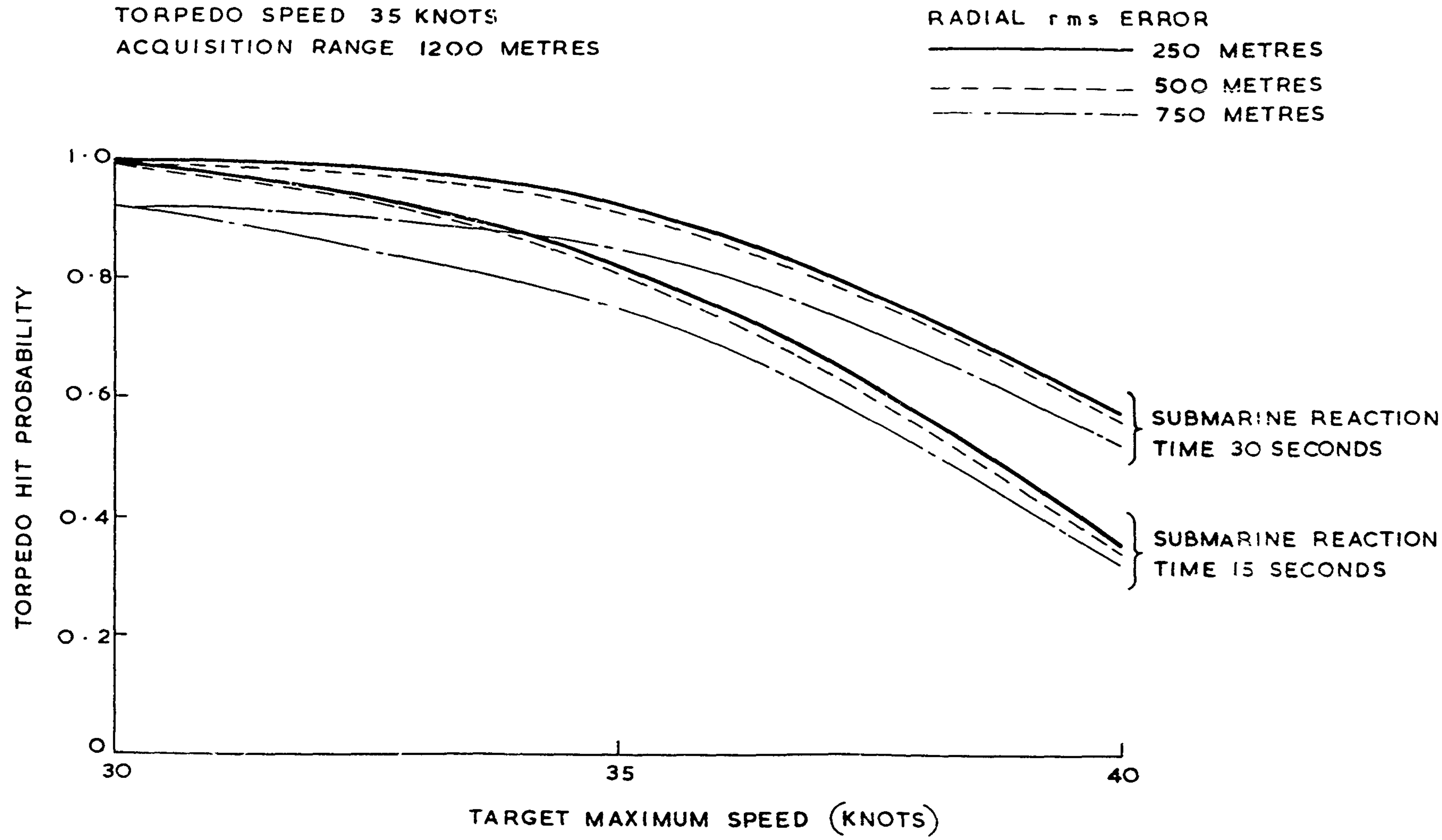

FIG. 15. MATCH ATTACK :- TORPEDO HIT PROBABILITY AGAINST TARGET MAXIMUM SPEED — ALERTED TARGET (INITIAL SPEED 10 KNOTS)

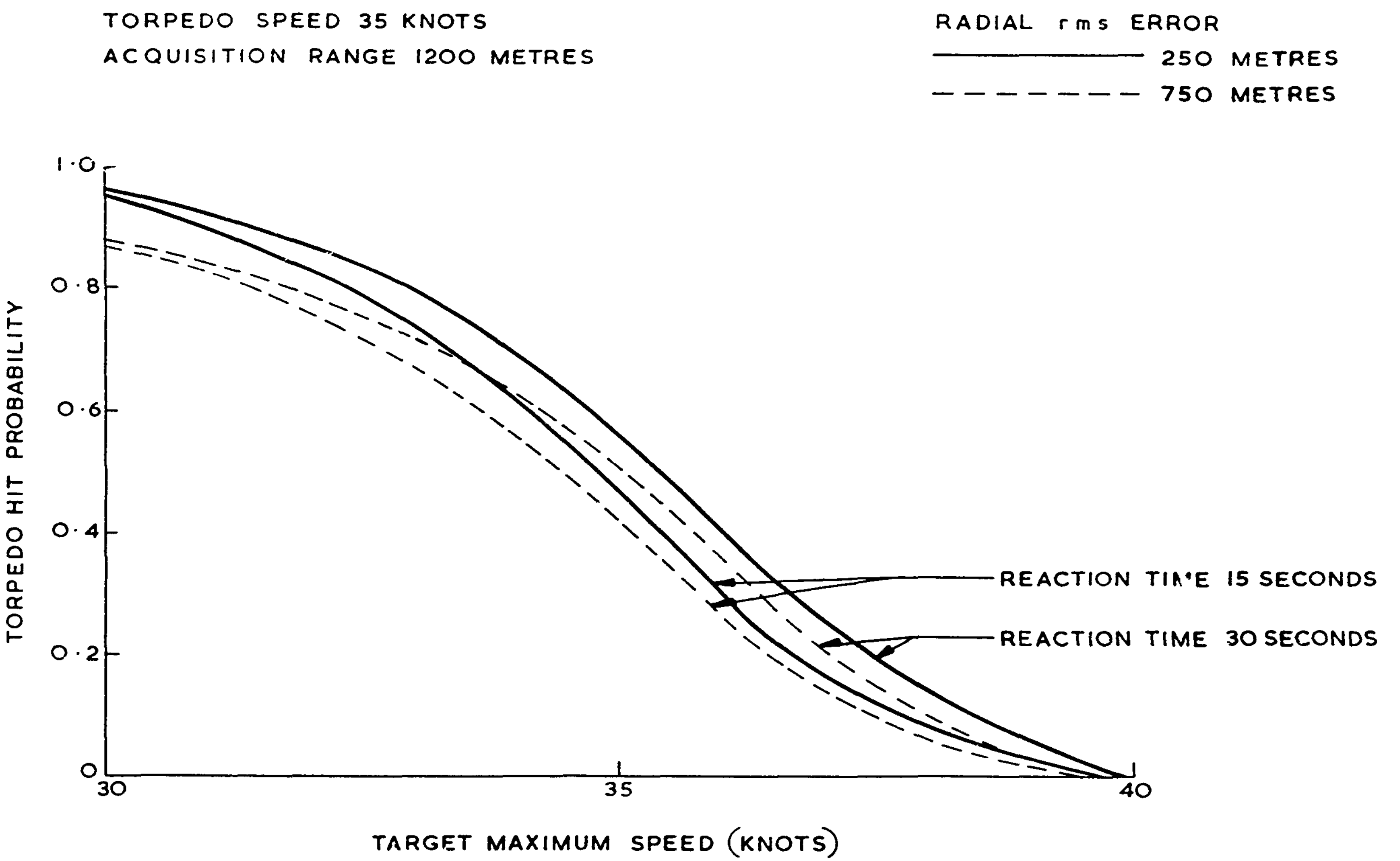

FIG. 16. MATCH ATTACK :- TORPEDO HIT PROBABILITY AGAINST TARGET MAXIMUM SPEED - ALERTED TARGET (INITIAL SPEED 20 KNOTS)

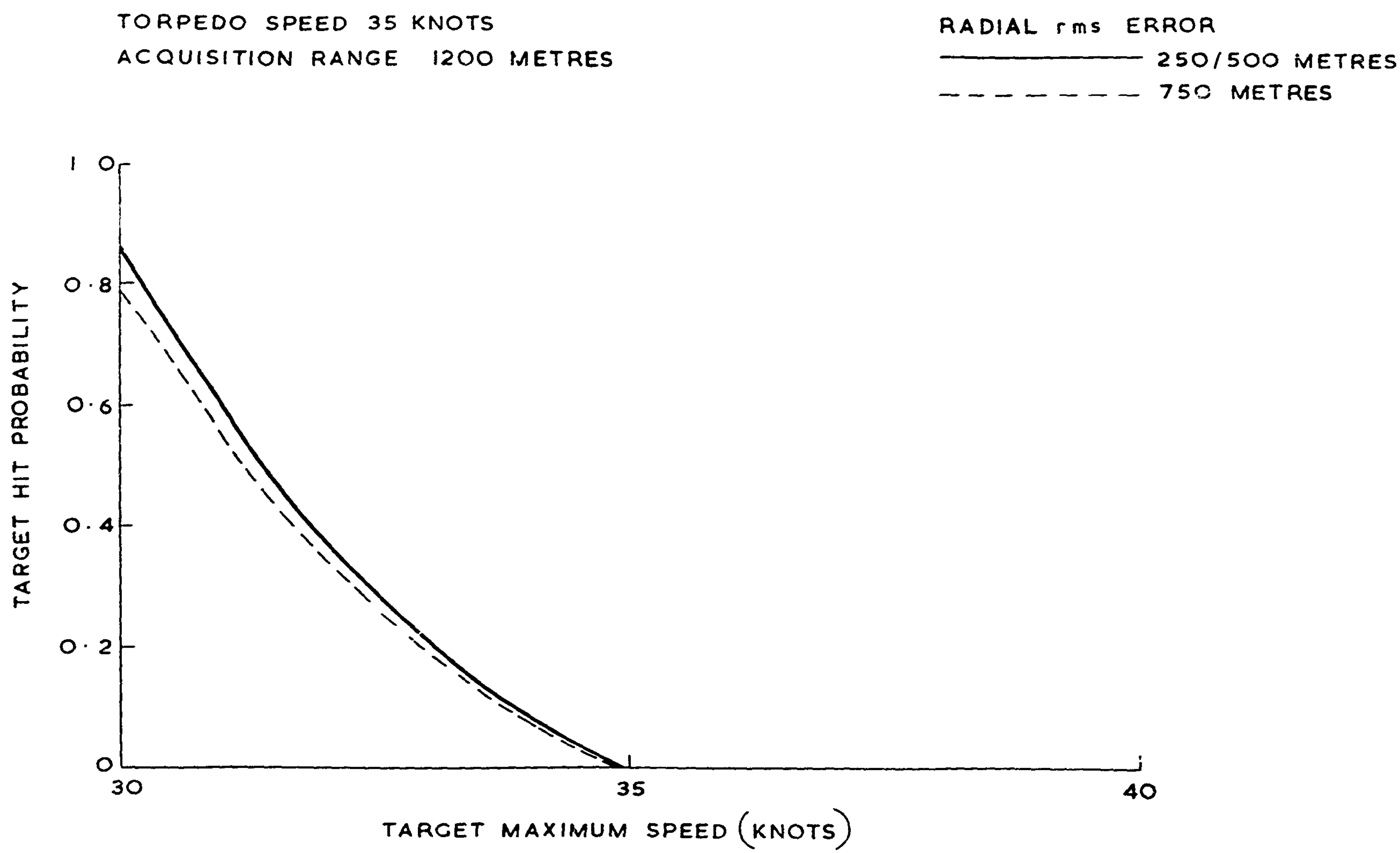

FIG. 17. MATCH ATTACK :- TORPEDO HIT PROBABILITY AGAINST TARGET MAXIMUM SPEED - UNALERTED TARGET

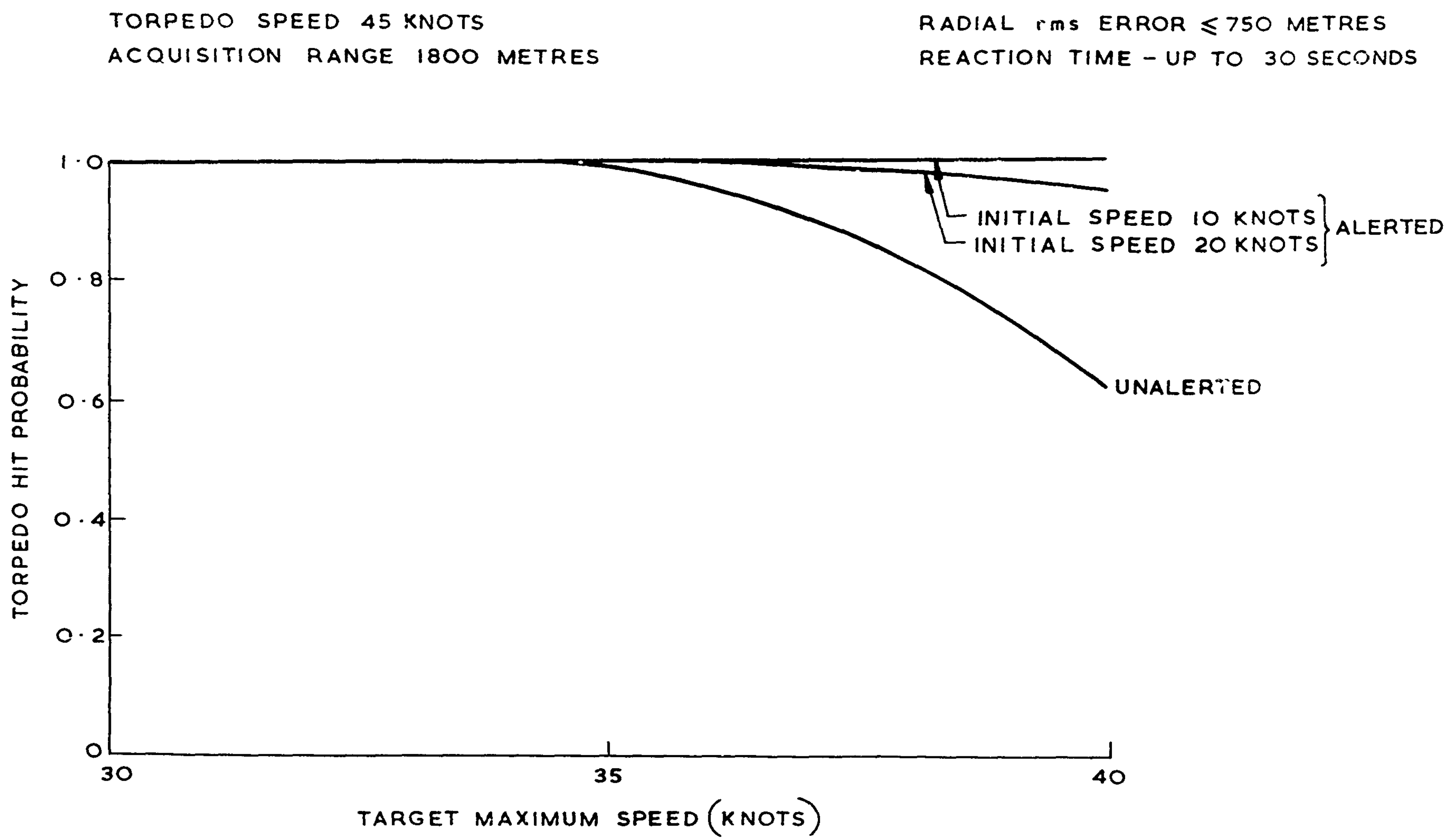

FIG. 18. MATCH ATTACK :- TORPEDO HIT PROBABILITY AGAINST TARGET MAXIMUM SPEED

U.K. ABSTRACT
NO.

(A)	Country of Origin	UNITED KINGDOM
(B)	Establishment of Origin with Short Address	Admiralty Underwater Weapons Establishment, Portland.
(C)	Title of Report	The Effect of Submarine Maximum Speed on the Hit Probability of an Air-Launched Torpedo (U)
(D)	Author	A.E. Jones
(E)	Pages and Figures	18 pages ((i) - (iii) (1 - 15)) Figs. 18
(F)	Date	March, 1973
(G)	Originator's Reference	Technical Note 484/73
(H)	Security Grading	SECRET
(J)	Abstract	This report provides a method of evaluating the effect of increased maximum submarine speed on the hit probability of an air-dropped torpedo. Curves are given which allow determination of torpedo hit probability as a function of target speed for various weapon systems, torpedo characteristics, and target characteristics. The theory is applied to systems involving the air-launched torpedo, and the parameter values are selected to show what could be achieved within the timescale of a future generation submarine. (R).

Detachable Abstract Cards

These abstract cards are inserted in A.U.W.E. reports and notes for the convenience of librarians and others who need to maintain an information index

ABSTRACT: RESTRICTED — **TECH. NOTE: SECRET**

A.U.W.E. Technical Note 484/73 — 623.946.21.1:
March, 1973 — 623.946.001.4:
A.E. Jones — 623.827.039.578

The Effect of Submarine Maximum Speed on the Hit Probability of an Air-Launched Torpedo (U)

This report provides a method of evaluating the effect of increased maximum submarine speed on the hit probability of an air-dropped torpedo. Curves are given which allow determination of torpedo hit probability as a function of target speed for various weapon systems, torpedo characteristics, and target characteristics. The theory is applied to systems involving the air-launched torpedo, and the parameter values are selected to show what could be achieved within the timescale of a future generation submarine.

ABSTRACT: RESTRICTED — **TECH. NOTE: SECRET**

A.U.W.E. Technical Note 484/73 — 623.946.21.1:
March, 1973 — 623.946.001.4:
A.E. Jones — 623.827.039.578

The Effect of Submarine Maximum Speed on the Hit Probability of an Air-Launched Torpedo (U)

This report provides a method of evaluating the effect of increased maximum submarine speed on the hit probability of an air-dropped torpedo. Curves are given which allow determination of torpedo hit probability as a function of target speed for various weapon systems, torpedo characteristics, and target characteristics. The theory is applied to systems involving the air-launched torpedo, and the parameter values are selected to show what could be achieved within the timescale of a future generation submarine.

ABSTRACT: RESTRICTED — **TECH. NOTE: SECRET**

A.U.W.E. Technical Note 484/73 — 623.946.21.1:
March, 1973 — 623.946.001.4:
A.E. Jones — 623.827.039.578

The Effect of Submarine Maximum Speed on the Hit Probability of an Air-Launched Torpedo (U)

This report provides a method of evaluating the effect of increased maximum submarine speed on the hit probability of an air-dropped torpedo. Curves are given which allow determination of torpedo hit probability as a function of target speed for various weapon systems, torpedo characteristics, and target characteristics. The theory is applied to systems involving the air-launched torpedo, and the parameter values are selected to show what could be achieved within the timescale of a future generation submarine.

ABSTRACT: RESTRICTED — **TECH. NOTE: SECRET**

A.U.W.E. Technical Note 484/73 — 623.946.21.1:
March, 1973 — 623.946.001.4:
A.E. Jones — 623.827.039.578

The Effect of Submarine Maximum Speed on the Hit Probability of an Air-Launched Torpedo (U)

This report provides a method of evaluating the effect of increased maximum submarine speed on the hit probability of an air-dropped torpedo. Curves are given which allow determination of torpedo hit probability as a function of target speed for various weapon systems, torpedo characteristics, and target characteristics. The theory is applied to systems involving the air-launched torpedo, and the parameter values are selected to show what could be achieved within the timescale of a future generation submarine.

[dstl]

Information Centre
Knowledge Services
[dstl] *Porton Down,*
Salisbury
Wilts
SP4 0JQ
Tel: 01980-613753
Fax 01980-613970

Defense Technical Information Center (DTIC)
8725 John J. Kingman Road, Suit 0944
Fort Belvoir, VA 22060-6218
U.S.A.

AD#: 597060
Date of Search: 20 December 2007

Record Summary:
Title: The effect of submarine maximum speed on the hit probability of an air-launched torpedo
Covering dates 1973
Availability Open Document, Open Description, Normal Closure before FOI Act: 30 years
Former reference (Department) AUWE Technical Note 484/73
Held by The National Archives, Kew

This document is now available at the National Archives, Kew, Surrey, United Kingdom.

DTIC has checked the National Archives Catalogue website (http://www.nationalarchives.gov.uk) and found the document is available and releasable to the public.

Access to UK public records is governed by statute, namely the Public Records Act, 1958, and the Public Records Act, 1967.
The document has been released under the 30 year rule.
(The vast majority of records selected for permanent preservation are made available to the public when they are 30 years old. This is commonly referred to as the 30 year rule and was established by the Public Records Act of 1967).

This document may be treated as UNLIMITED.

the national archives

| › Contact us | › Help | › A to Z index | › Site search |
› Accessibility

AD 594060

Remove X

MyPage | Sign in | Register

You are here: Home > Search the archives > the Catalogue > Search the catalogue: Results summary

type reference here

Go to reference ›

the Catalogue

Welcome : About Research guides
Search Browse ? Help Search

Search the catalogue: Results

? Help : search results

Search Places, prominent people & subjects

Show advanced options

Results:

Refine search ›

You ran a search on "**air-launch torpedo**"
There is **1** result within The Catalogue.

Download results ⌄

Catalogue:

Sort by: Catalogue reference ⌄ | Former reference ⌄ | Date range ⌄ | Relevance ranking ⌄

Catalogue Reference	Title/Scope and Content	Covering Dates
ADM 302/534	*i* The effect of submarine maximum speed on the hit probability of an air-launched torpedo	1973

Download results ⌄

Refine search ›

Catalogue Reader v2.3.5